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THE COLPITTS OSCILLATOR FAMILY

E. Lindberg¹, K. Murali² and A. Tamasevicius³

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³Plasma Phenomena and Chaos Laboratory, Semiconductor Physics Institute,
A. Gostauto 11, Vilnius, LT-01108, Lithuania

Abstract

A tutorial study of the Colpitts oscillator family defined as all oscillators based on a nonlinear amplifier and a three-terminal linear resonance circuit with one coil and two capacitors. The original patents are investigated. The eigenvalues of the linearized Jacobian for oscillators based on single transistors or operational amplifiers are studied.

Introduction

An electronic oscillator is a nonlinear circuit with at least two memory components (charge, flux or hysteresis based). When excited with a dc source an oscillator responds with a steady state signal which may be chaotic in nature in case of more than two memory components. The Colpitts oscillator is one of the most used oscillators especially for high frequencies. The aim of this tutorial is to study Colpitts oscillators defined as any oscillator made from a nonlinear amplifier and a three-terminal linear resonance circuit with one coil and two capacitors called the **Colpitts resonator**.

Electronic oscillators may be classified in families according to the kind and number of memory elements used e.g. the common multi-vibrator family with one capacitor or one coil in connection with a nonlinear amplifier [1], the Wien Bridge family where one RC-series and one RC-parallel circuit occur [2], the negative resistance family where one simple LC resonance circuit occur [3], the Colpitts family where a resonance circuit with two capacitors and one coil occur or the Hartley family where a resonance circuit with two coils and one capacitor occur.

Many years ago when the words "oscillator" and "electronics" were not invented in connection with electrical circuits and systems an "*Oscillation Generator*" was invented by Edwin Henry Colpitts (1872-1949) possibly sometime in the period 1915-1918. Colpitts oscillator topology based on two capacitors and one coil is the electrical dual of Hartleys oscillator topology based on two coils and one capacitor. Colpitts patents are investigated. This tutorial is divided into three sections. First general comments on amplifiers and oscillators, then transistor based Colpitts oscillators and finally Colpitts oscillators based on operational amplifiers are investigated.

Amplifiers and Oscillators

There are four types of **amplifiers** or controlled sources - Voltage Controlled Voltage Source VCVS, Voltage Controlled Current Source VCCS, Current Controlled Voltage Source C CVS and Current Controlled Current Source CCCS. Amplifiers are characterized by a stable time invariant dc bias point which may be used as signal reference. For small signals we have a linear relation between output and input. For large signals we may observe distortion of the signals.

A general amplifier circuit with four impedances is investigated. Two impedances are used for positive- and two impedances are used for negative- feed-back. If we introduce memory elements - capacitors, coils, hysteresis - in the four impedances various types of oscillators may be obtained. With three resistors and one capacitor or one coil four different common multi-vibrator topologies may be obtained [1].

Normally you distinguish between sinusoidal and relaxation **oscillators** but this is not a proper division because the same topology may give rise to both kinds of oscillations at different frequencies [1]. Oscillators are circuits which for constant input signal (dc battery) produce an oscillating output signal (a steady state time varying signal). Oscillators do not have a stable time invariant dc bias point which can be used as signal reference but some times an average bias point is introduced. There are three basic types of oscillators. The **first** type has an unstable initial dc bias point. This

type is self-starting when the power supply is connected. The eigenvalues of the linearized Jacobian of the differential equations - the poles - are moving between the right half (RHP) and the left half (LHP) of the complex frequency plane so that a balance is obtained between the energy obtained from the power supply when the poles are in RHP and the energy lost when the poles are in LHP. The **second** type has a stable initial dc bias point. This type needs some extra initial energy in order to start up. The poles are in LHP all the time and some special impulse mechanism is needed to provide energy from the power supply in the steady state. The **third** type is a combination of the two types. It is unstable in the initial dc bias point and the poles are moving around in LHP only in the steady state [4,5].

The frequency of the oscillator is primarily determined by the imaginary part of the complex pole pair (eigenvalue) of the linear resonance circuit involved. The amplitude of the oscillator is primarily determined by the real part of the complex pole pair. If the oscillator is a second order circuit with two linear memory components and a nonlinear amplifier it is impossible to obtain an almost constant frequency corresponding to balancing on the razor's edge with the complex pole on the imaginary axis. If the oscillator is a third order circuit with three linear memory components then you may have an extra real pole in connection with the complex pole pair to operate with corresponding to the balancing pole of the tight-rope walker.

Colpitts Oscillators based on Transistors

It is difficult to obtain a complete systematic description of all the possible topologies of the Colpitts oscillator family because it is a third order system. The Colpitts resonator is normally introduced as a triangle circuit but a star circuit with a coil and two capacitors may also be used [6]. Colpitts oscillators based on a single transistor as amplifier in common emitter-, base- or collector-mode are compared.

Experiments with PSpice simulations are presented. A 100kHz Colpitts resonator is designed. Losses are introduced as a resistor in series with the coil because it is impossible in practice to neglect the coil losses. The two capacitors are of different size because it is difficult in practice to obtain exact same value.

The 3 terminals of the transistor may be combined with the 3 terminals of the Colpitts resonator in many ways e.g. by rotating the components of the resonator. A total of 18 topologies have been investigated. It was found that 6 of these gave rise to steady state oscillations. PSpice models for transistors 2N2222 and 2N3904 were used. If a simple Ebers-Moll transport-model with no feed-back for the transistor is introduced only one nonlinearity occur (diode) and the trajectories of the poles in the complex frequency plane may easily be found. A complex pole pair is moving between RHP and LHP and a real pole is moving on the negative real axis. The imaginary part of the complex pole pair is almost constant giving rise to very little phase noise.

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Conclusion

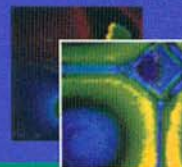
The Colpitts oscillator family is investigated. New oscillator topologies with memory components in both positive and negative feed-back path of a perfect operational amplifier are presented. The complex frequency plane trajectories of the eigenvalues of the linearized Jacobian of the differential equations modeling topologies with only one nonlinearity are studied in order to obtain knowledge about the mechanism behind the oscillations [5]. A real pole is moving in the left half plane and a complex pole pair is moving between the right and the left half plane so that energy balance is obtained.

References

1. Erik Lindberg, K. Murali and Arunas Tamasevicius "The Common Multi-Vibrator Family", Proceedings of The 15th IEEE International Workshop on Nonlinear Dynamics of Electronic Systems - NDES'07, Tokushima, Japan, July 23-26, 2007, pp. 180-183.
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3. E. Lindberg, "Oscillators and operational amplifiers", Proceedings European Conference on Circuit Theory and Design, ECCTD'05, Sept. 2005, vol.2, pp. 19-22, IEEE Xplore, IEEE, 2005.

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5. E. Lindberg, "Is the Quadrature Oscillator a Multivibrator ?", IEEE Circuits & Devices Magazine, November/December 2004, vol. 20, no. 6, pp. 23-28, 2004.
6. R. Rhea, "A new class of oscillators", IEEE Microwave Magazine, Vol.5, No.2, pp. 72-83, 2004.

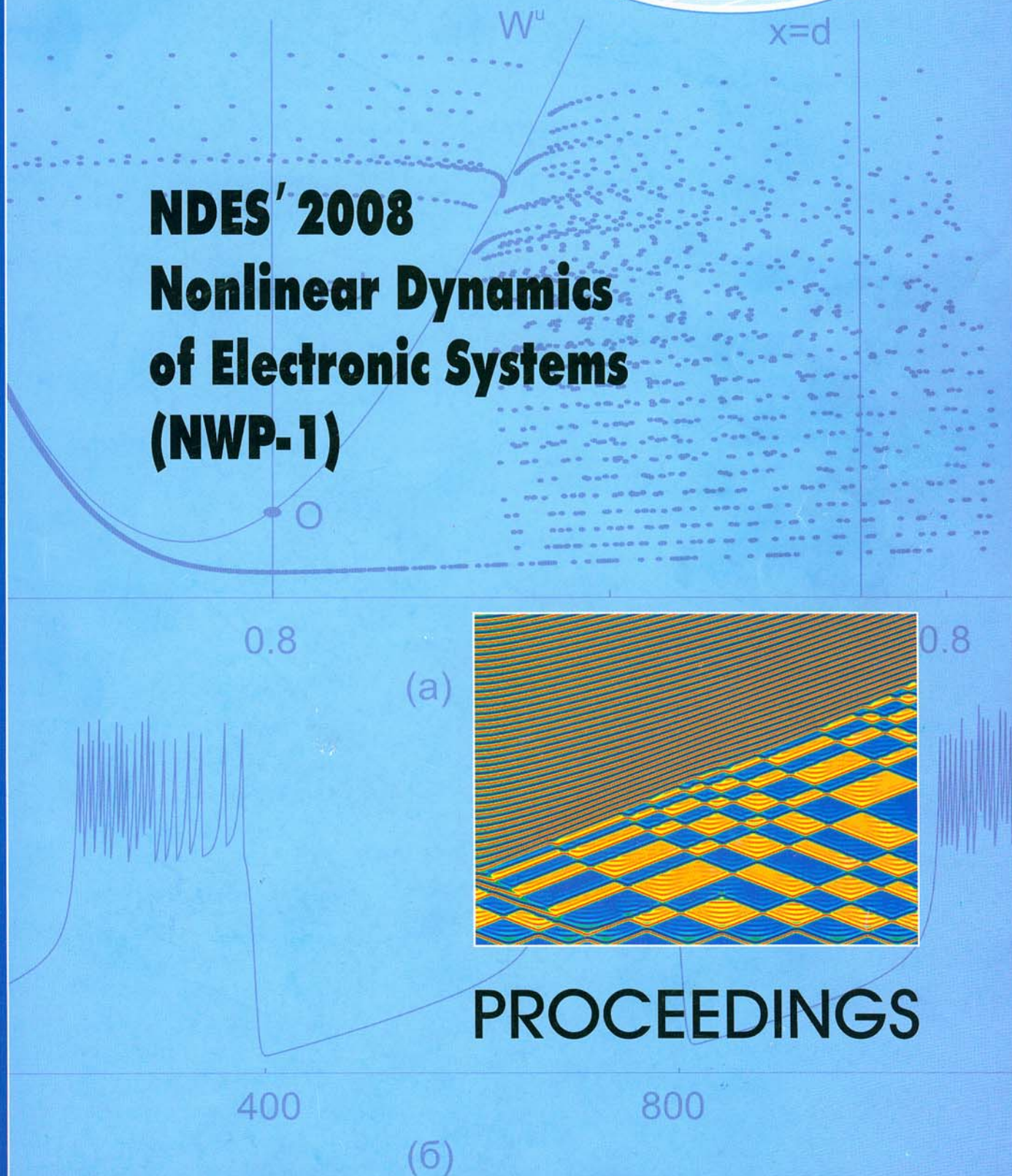
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TOPICAL PROBLEMS OF NONLINEAR WAVE PHYSICS
(NWP-2008)



Nizhny Novgorod, Russia
20-26 July, 2008



NDES' 2008
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International Symposium

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TOPICAL PROBLEMS OF NONLINEAR WAVE PHYSICS (NWP-2008)

International Symposium

NDES'2008
(NWP-1)

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THE COLPITTS OSCILLATOR FAMILY

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1 Colpitts Oscillator Family

2 Amplifiers and Oscillators

3 Colpitts Oscillators based on Transistors

4 Colpitts Oscillators based on Amplifiers

5 Conclusion

A tutorial study of

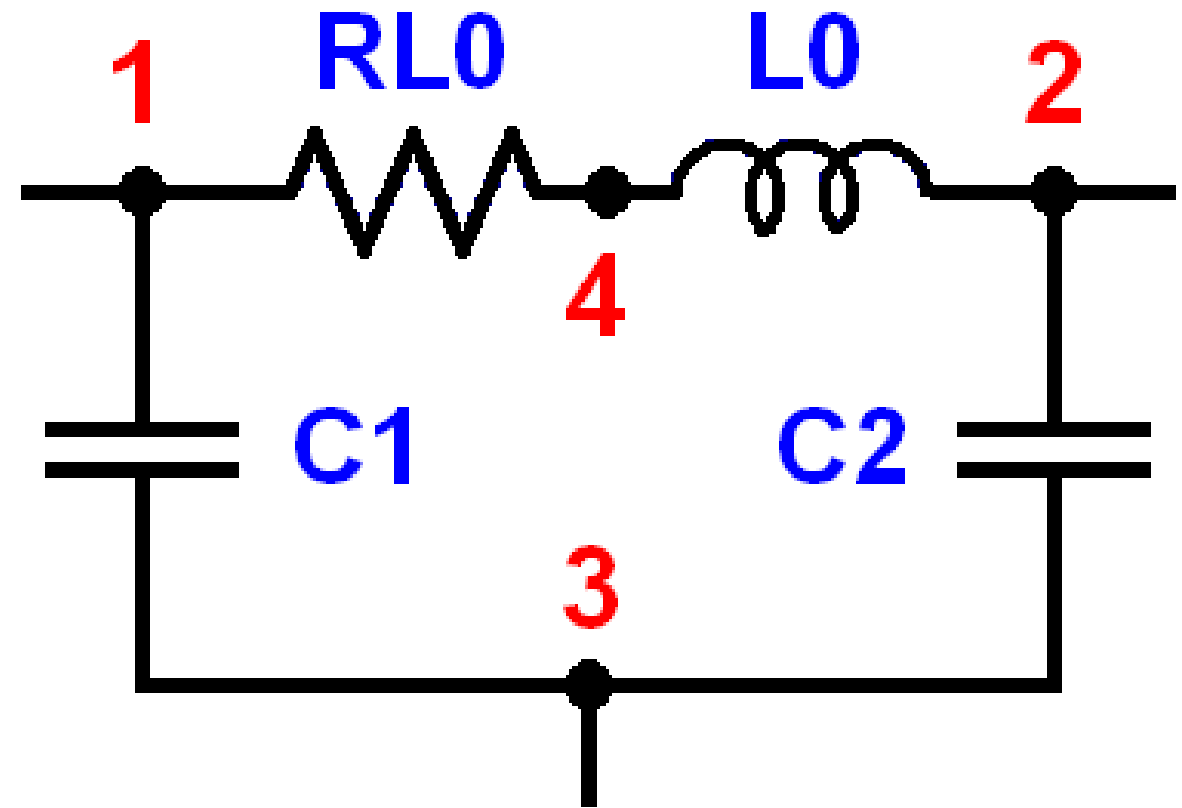
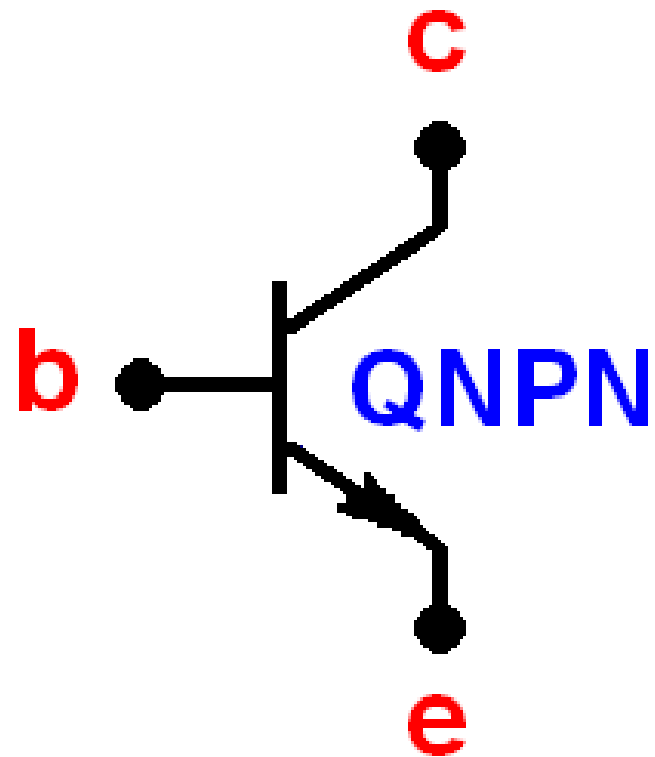
the Colpitts oscillator family

defined as

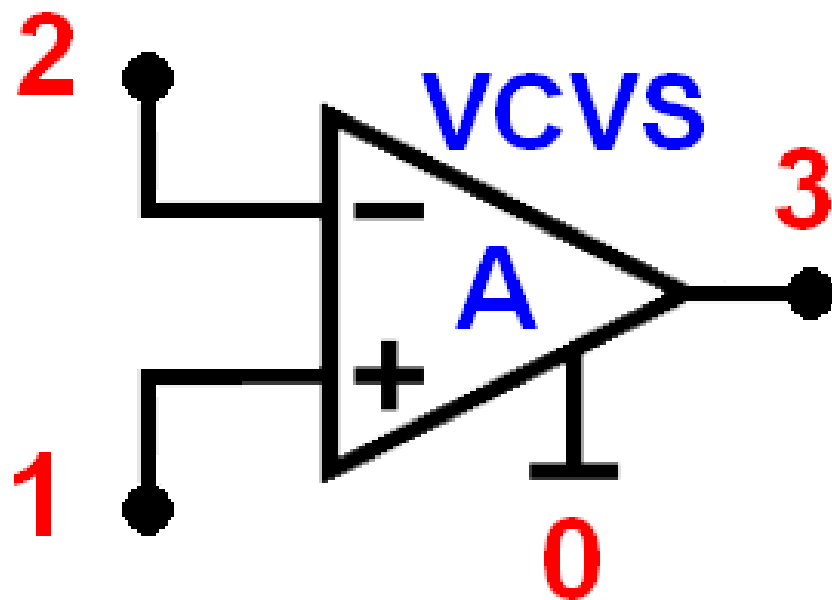
**all oscillators based on
a nonlinear amplifier**

and

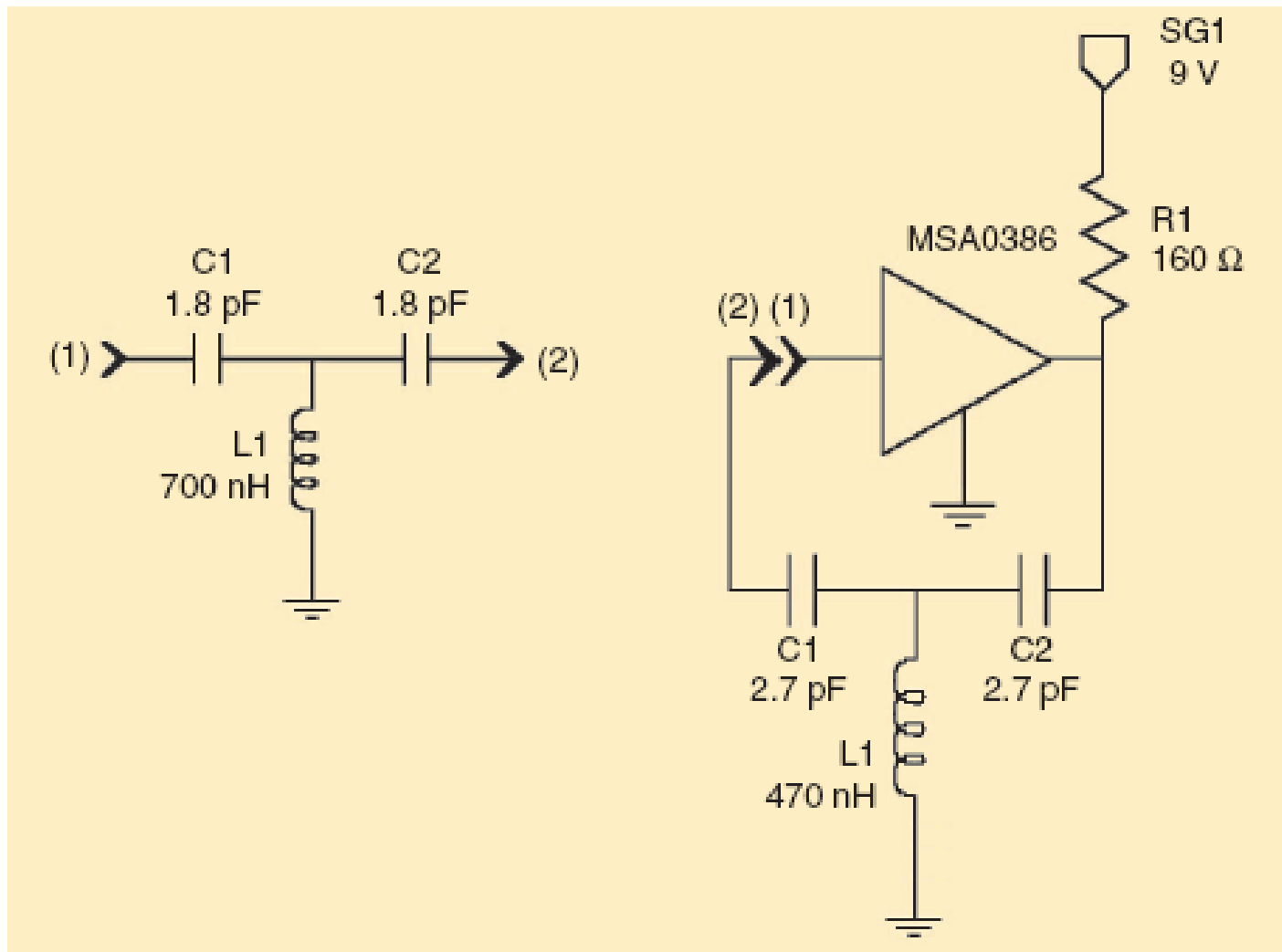
**a three-terminal
linear resonance circuit
with one coil and two capacitors**



Colpitts
Resonator



3'rd order



**Rhea, R., "A new class of oscillators",
IEEE Microwave Magazine, Vol.5 Issue.2, pp 72-83, 2004**

The Colpitts Oscillator Family

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"Oscillation Generator"
was invented by
Edwin Henry Colpitts (1872-1949)
possibly sometime in
the period 1915-1918**

The Colpitts Oscillator Family

Patented Apr. 12, 1927.

1,624,537

UNITED STATES PATENT OFFICE.

EDWIN H. COLPITTS, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

OSCILLATION GENERATOR.

Application filed February 1, 1918. Serial No. 214,971.

It is known that a vacuum tube of the audion type may be employed as a generator of oscillations of any desired frequency by providing a tuned circuit suitably associated with the tube circuits, usually called input oscillations of any frequency, depending upon the values of inductance and capacity in the oscillating circuit. 55

The operation of the system may be explained as follows:

OSCILLATION GENERATOR.

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It is known that a vacuum tube of the audion type may be employed as a generator of oscillations of any desired frequency by providing a tuned circuit suitably associated
5 with the tube circuits, usually called input and output circuits. In previous generators the coupling between the input and output circuits has been electro-magnetic. In accordance with this invention, the couplings
10 between the input circuit and the oscillation circuit and between the output circuit and the oscillation circuit are made electrostatic. Some of the advantages of this arrangement are herein enumerated. One advantage of
15 this form of generator is that the generation of oscillations of a frequency not determined by the period of the tuned circuit is prevented. Another advantage is that it enables the generator to be connected to an
20 antenna in a transmitting system without causing any part of the generator to be short-circuited. This and other novel advantages will be most readily understood by reference to the following detailed description taken in connection with the accompanying drawings, in which Fig. 1 represents one form of the generator of this invention; Fig. 2 is a modification of Fig. 1; and Fig. 3 illustrates how the generator may
25 be associated with a transmitting antenna.
30

Referring to Fig. 1, 6 is an evacuated vessel of the audion type containing a filament 7, an anode 8 and a grid or im-

oscillations of any frequency, depending upon the values of inductance and capacity 55 in the oscillating circuit.

The operation of the system may be explained as follows:

Assume that a slight disturbance is impressed upon the grid 9. Corresponding 60 changes but of greater amplitude will then occur in the output circuit current from the source of voltage 11. Due to the mutual capacity reactance 13 between the output circuit and the oscillating circuit, these current changes in the output circuit will set
65 up oscillations in the oscillating circuit of a period determined by the amount of inductance and capacity in the circuit. The current in the oscillating circuit will create
70 an alternating current voltage drop across the terminals of the condenser 16, and since this condenser is common to both the input circuit and the oscillating circuit, the alternating voltage will be impressed between
75 the grid 9 and the filament 7. This voltage will then cause corresponding current variations in the output circuit as explained above, so that the cycle of operations will
80 be repeated and the tube will be caused to generate oscillations of constant amplitude and of a frequency determined by the tuning of the oscillating circuit. These oscillations may be impressed in any suitable manner, as by a transformer 22, upon a work circuit 85 23, whereby the oscillations may be em-

The Colpitts Oscillator Family

The drawings of Colpitts's

**US patent (filed 1918, issued 1927),
1,624,537 and his**

**Canadian patent (filed 1919, issued 1920)
203986 are identical**

April 12, 1927.

E. H. COLPITTS

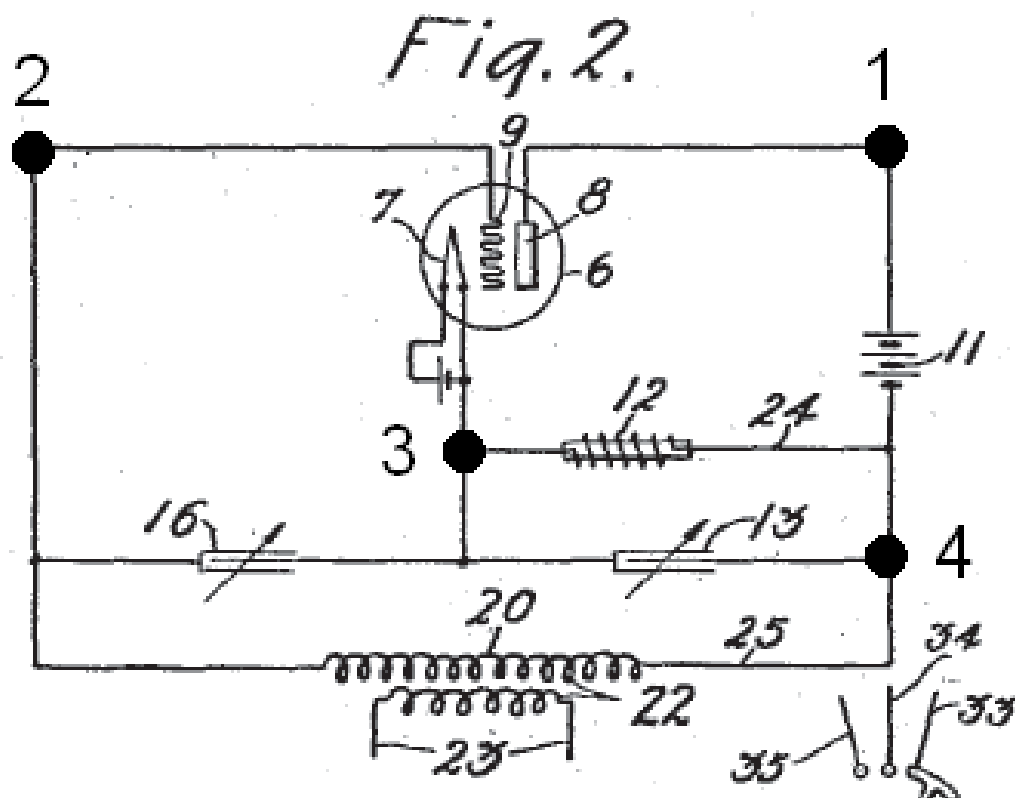
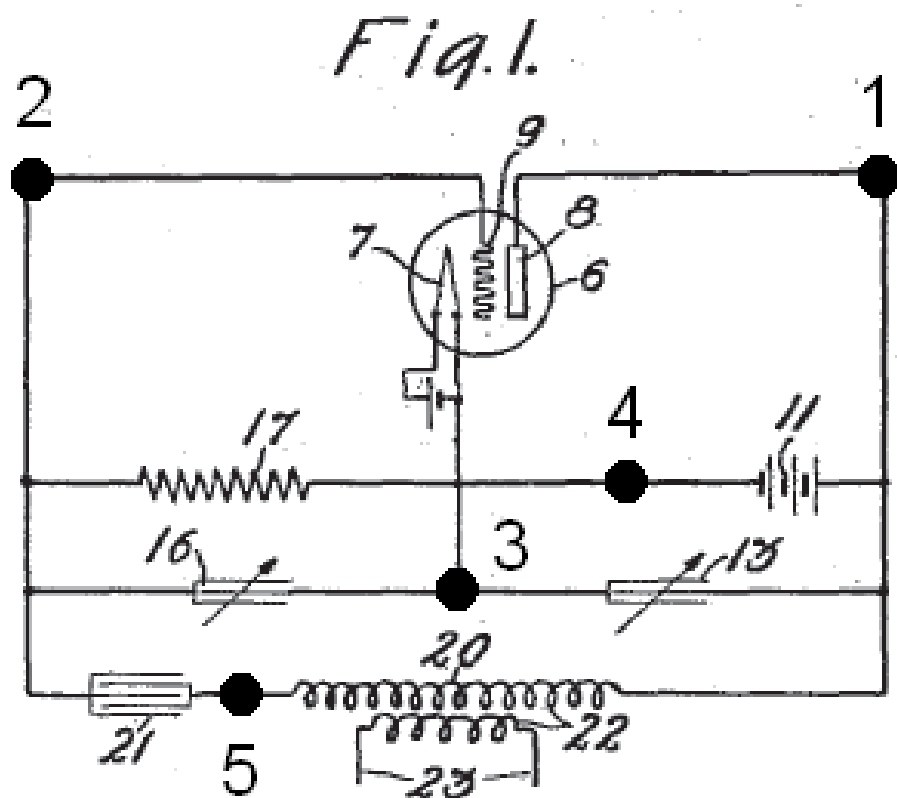
OSCILLATION GENERATOR

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US

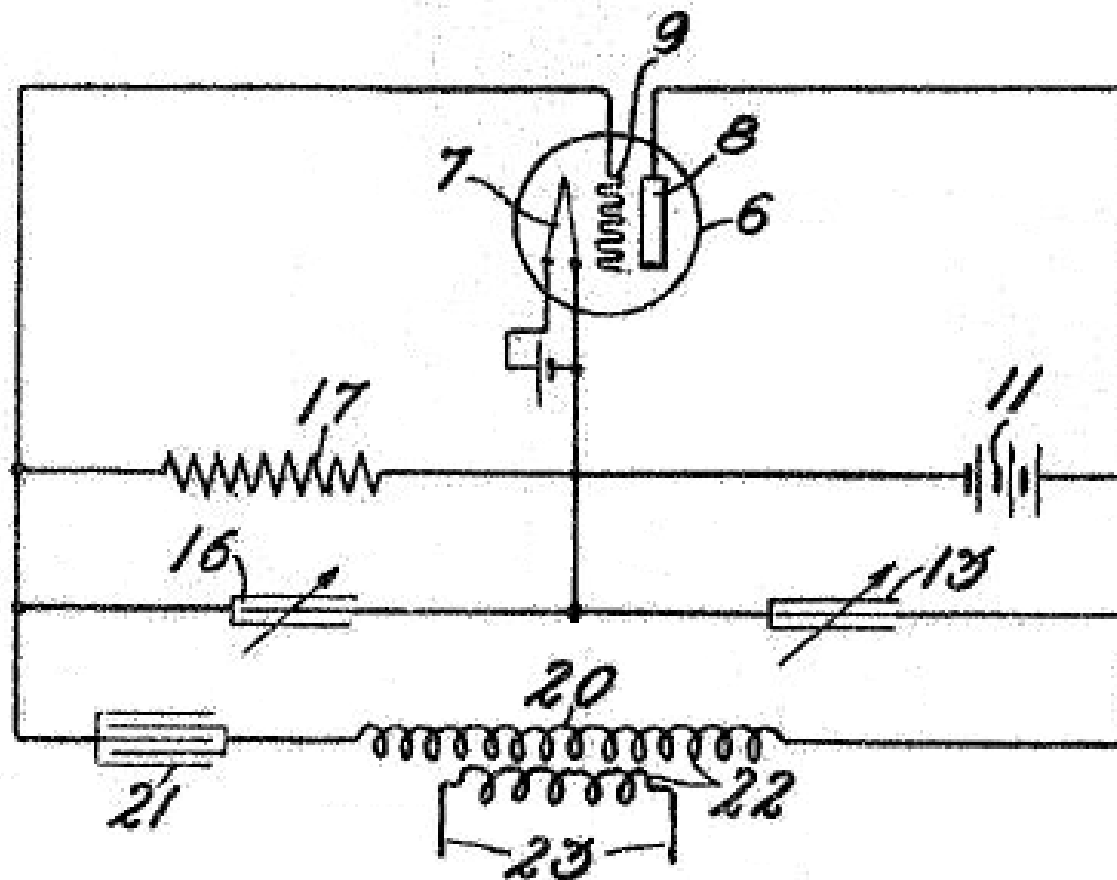
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ca

Oscillation Generator

203986

Fig. 1.



**Colpitts's
Canadian Patent
filed 1919
issued 1920**

The Colpitts Oscillator Family

**Colpitt's oscillator topology
based on two capacitors and one coil
is the electrical dual of
Hartley's oscillator topology
based on two coils and one capacitor.**

**Hartley's patent was
filed 1915 and issued 1920.**

The Colpitts Oscillator Family

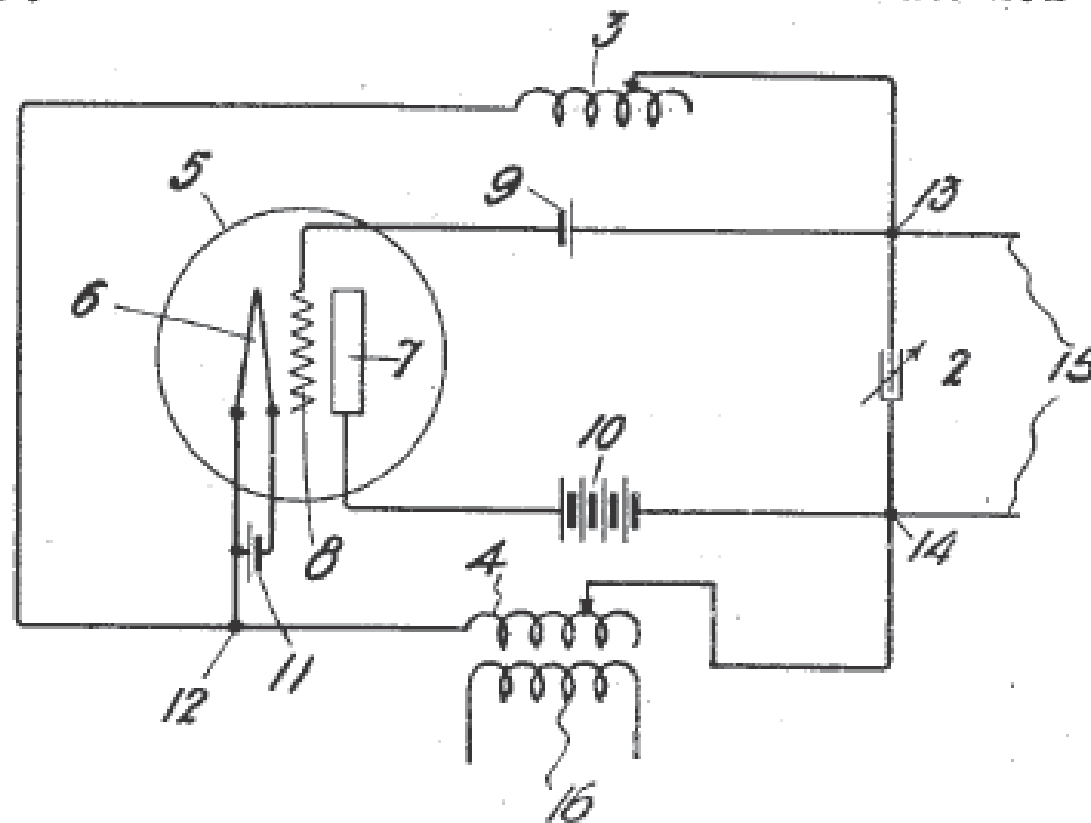
R. V. L. HARTLEY.

OSCILLATION GENERATOR.

APPLICATION FILED JUNE 1, 1915.

1,356,763.

Patented Oct. 26, 1920.



The Colpitts Oscillator Family

**It is interesting to observe that the
topology with
"a stopping condenser of large capacity
(21)"
in series with the coil (20)
"to prevent the flow of direct current"
- now known as the
 Clapp oscillator
- is included.**

April 12, 1927.

E. H. COLPITTS

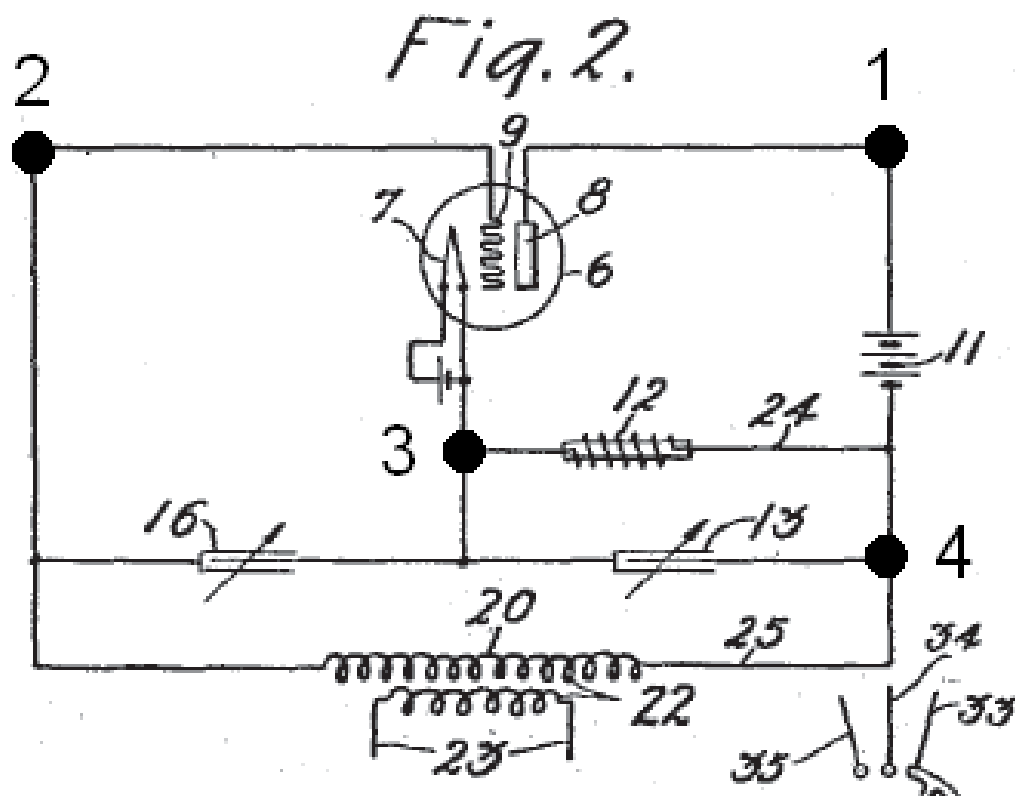
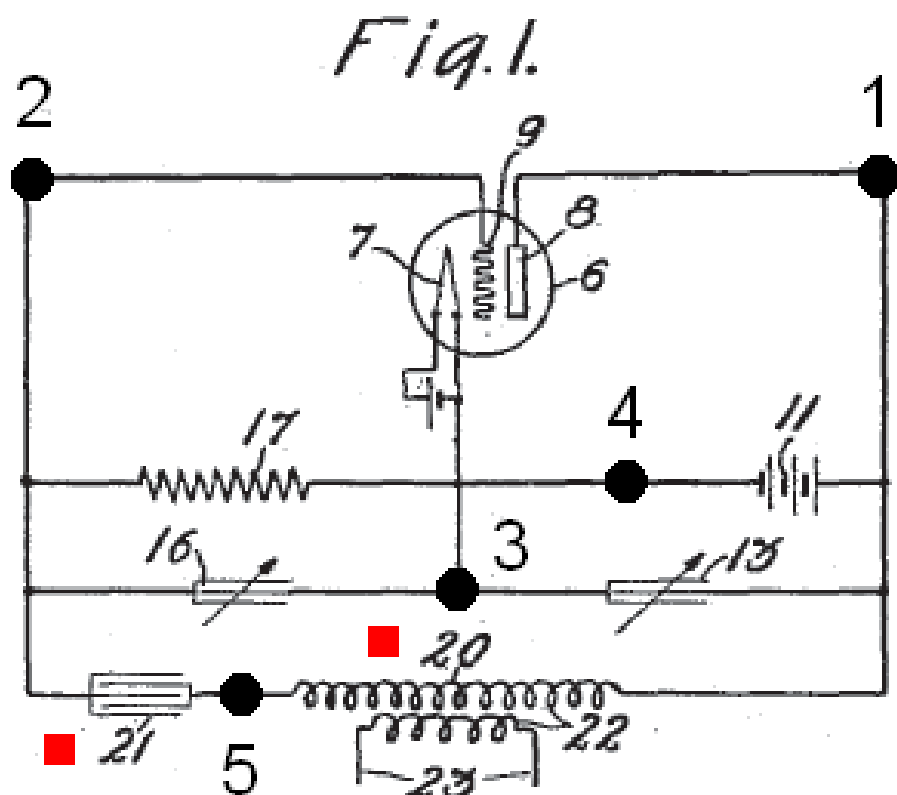
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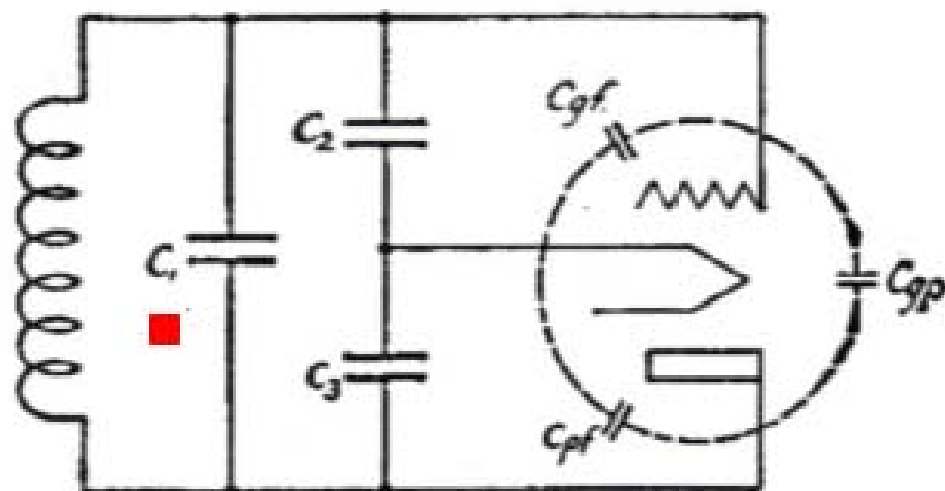
1,624,537

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203986

ca

Clapp ! 



g grid
f filament = cathode
p plate = anode

FIG. 1. THE ADVANTAGES OF A COLPITTS CIRCUIT EXPLAINED

Each tube capacity is shunted by a condenser which must be large for best results. In the set here described C2 and C3 each have a fixed capacity of 400 μfd and C1 has a maximum capacity of 250 μfd . Thus the capacity across the coil may be as large as 650 μfd . It is never made less than 420 μfd . This should be compared with ordinary amateur practice.

Dudley, Beverly, "A low-power master-oscillator transmitter",
Q.S.T. American Radio Relay League,
Vol.12 Issue.2, pp 10-14, 1928

Frozen Eigenvalues Approach

the circuit is linearized at a certain moment and the placements in the complex frequency plane of the eigenvalues of the Jacobian are found

pole trajectories in LHP and RHP

Colpitts 3'rd order i.e.

3 real poles or

1 real pole and 1 complex pole pair

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VCVS **VCCS** **CCVS** **CCCS**

"mu"

"gm"

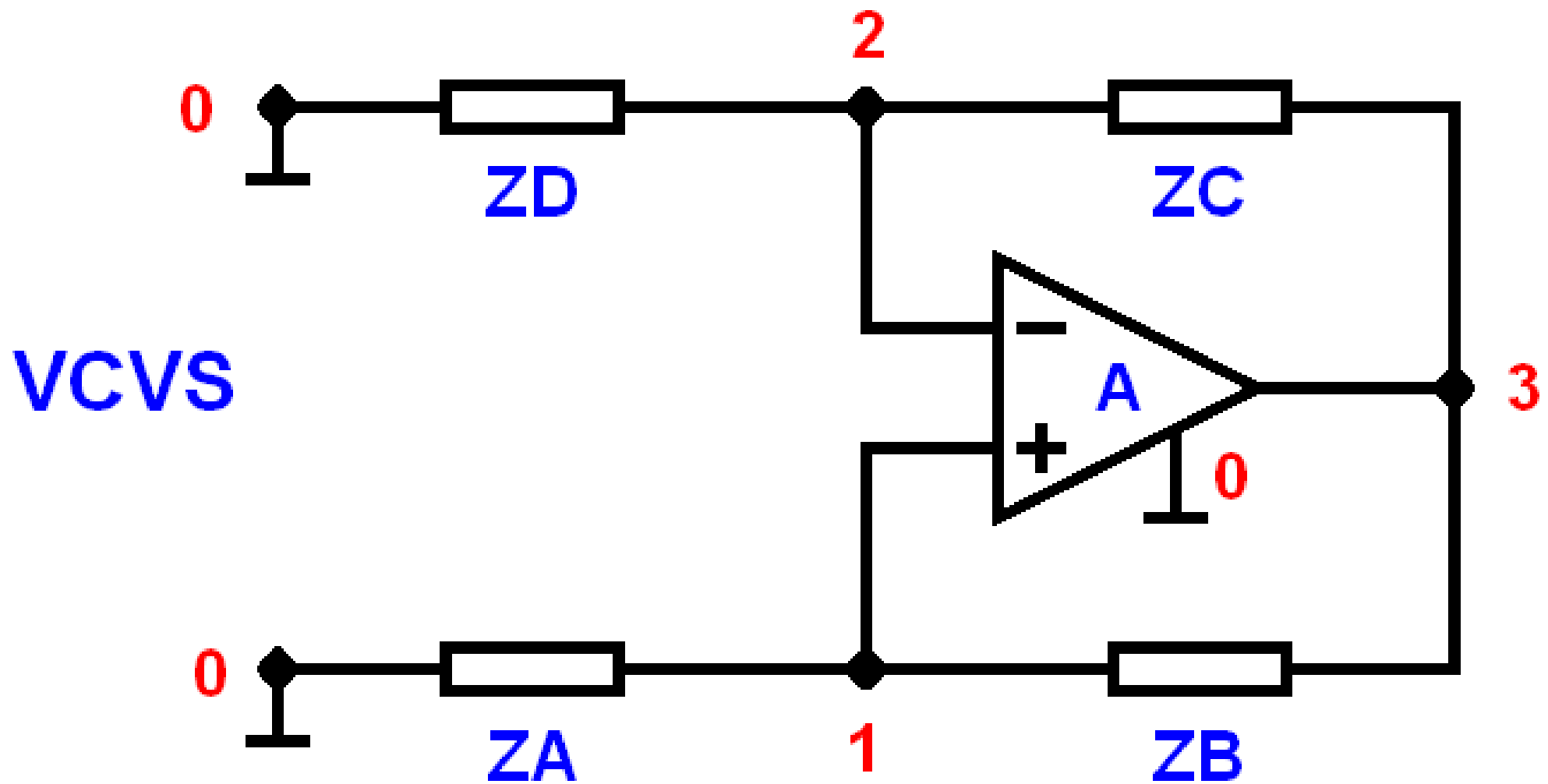
"rm"

"beta"

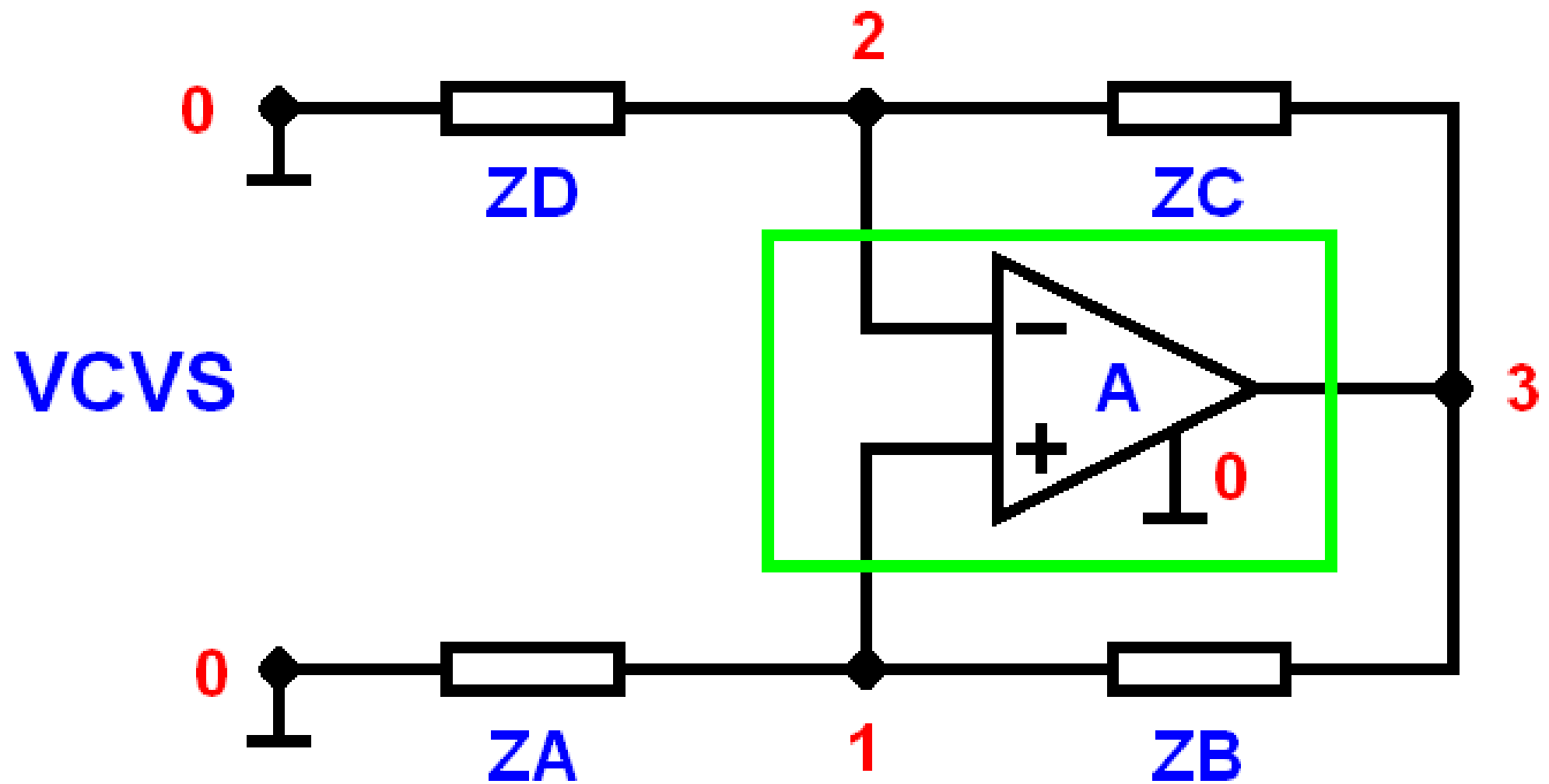
Stable time invariant dc bias point
signal reference

Small signals: linear transfer

Large signals: nonlinear transfer
distortion



Amplifier with
positive and negative feed-back

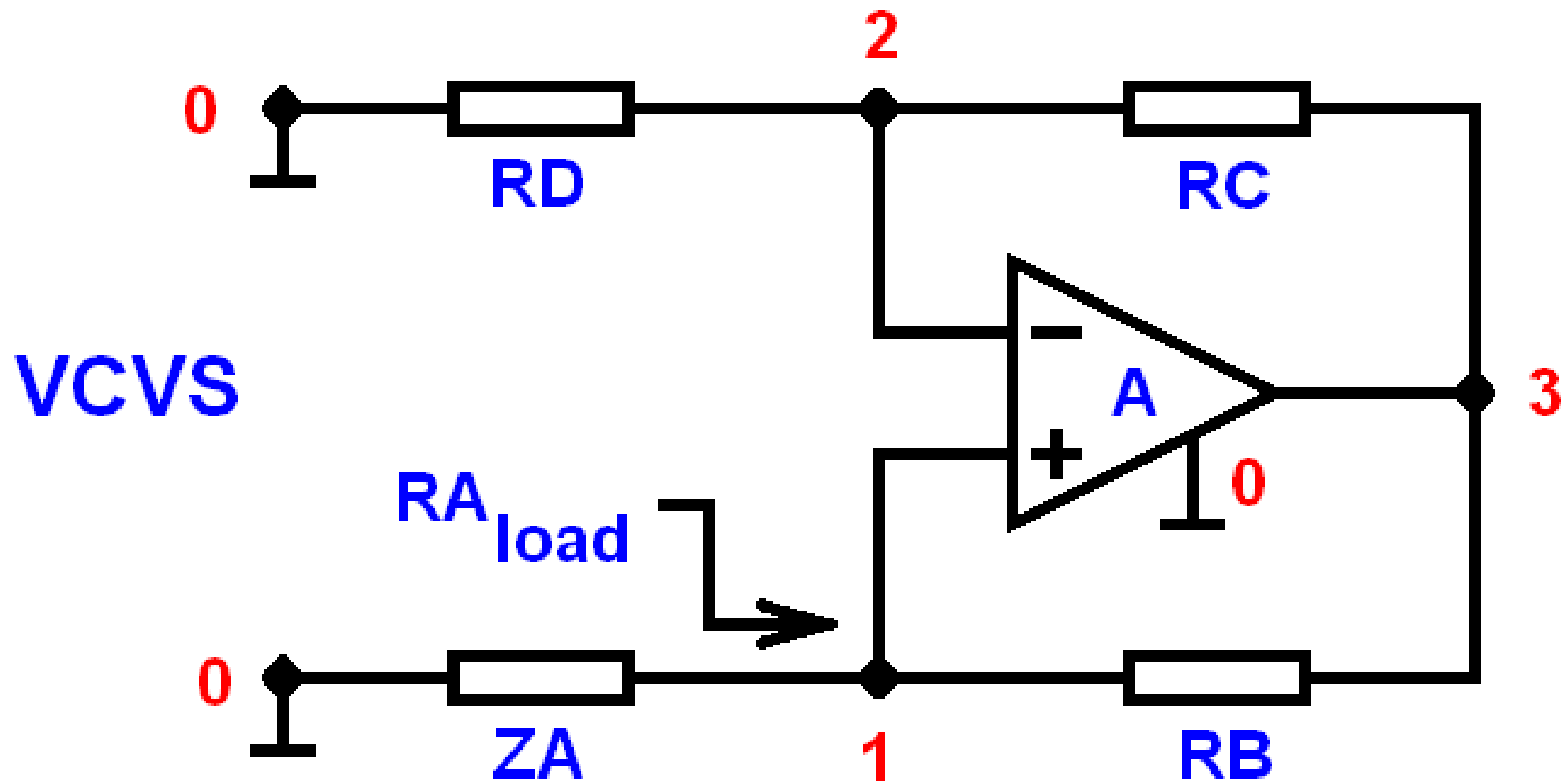


Perfect amplifier:

$$Z_{\text{in}} = \infty$$

$$Z_{\text{out}} = 0$$

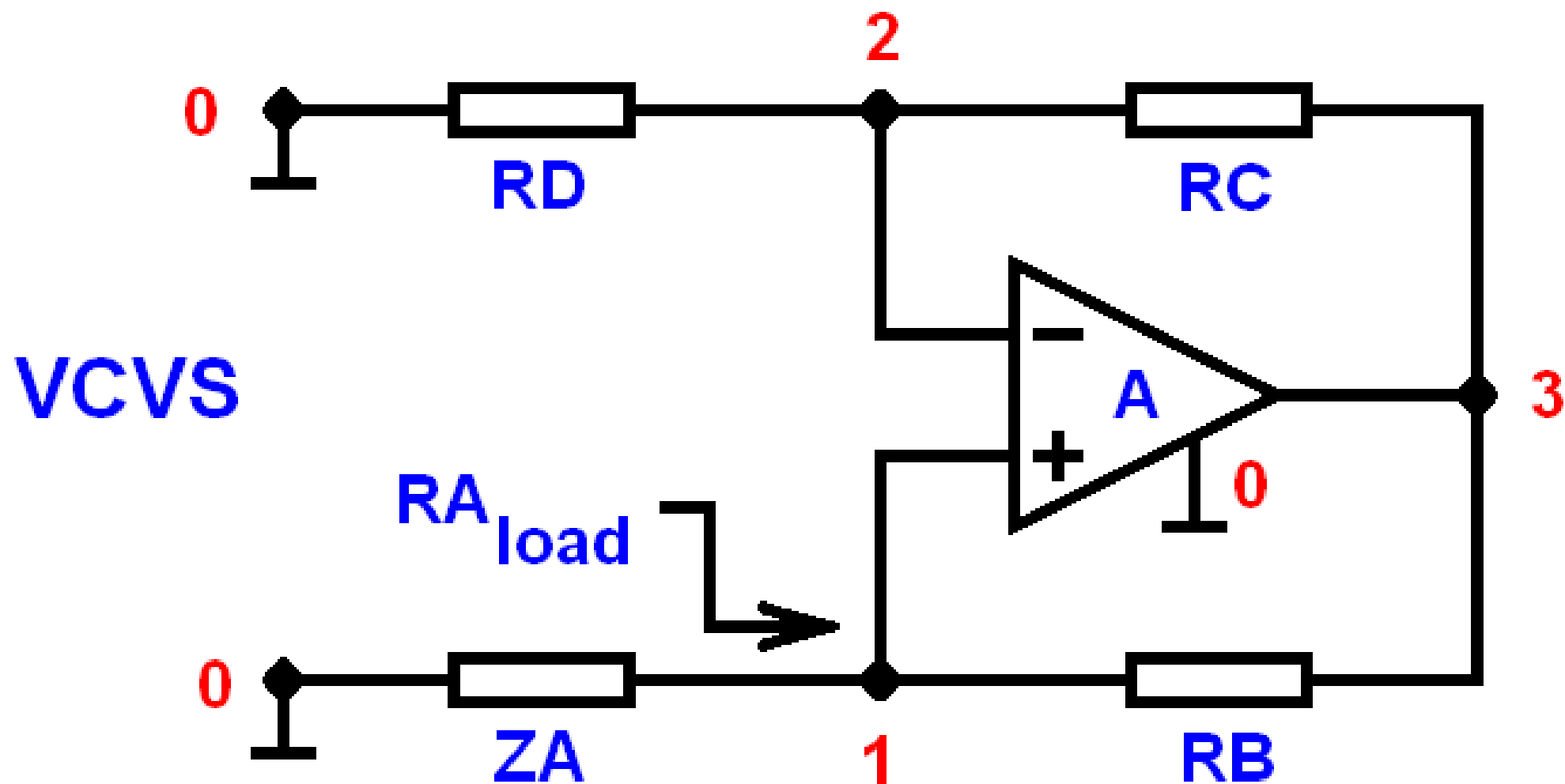
$$V_3 = A * (V_1 - V_2)$$



$$A = \infty \quad R_{A_{load}} = - \frac{R_B * R_D}{R_C}$$

$$A = 0 \quad R_{A_{load}} = + R_B$$

**Negative
Resistance**



$$R_{A_{load}} = 0 \quad \text{for} \quad A = - \left(1 + \frac{R_C}{R_D} \right)$$

$$R_{A_{load}} = \infty \quad \text{for} \quad A = + \left(1 + \frac{R_D}{R_C} \right)$$

Oscillators are nonlinear circuits.

The **Barkhausen criteria** will only give you a starting point as a **"linear oscillator"** with a complex pole pair on the imaginary axis

**not sufficient for
steady state oscillations**

In most cases you are lucky and your circuit will oscillate for some reason

Oscillators are nonlinear circuits.

**The Barkhausen Stability Criterion
is simple, intuitive, and wrong ;-).**

<http://web.mit.edu/klund/www/weblatex/node4.html#SECTION00041000000000000000>

Kent H Lundberg

2002-11-14

Barkhausen criteria

Vimal Singh,

"A note on determination of oscillation startup condition",
Analog Integr. Circ. Sig. Process (Springer 2006),
vol.48, pp.251–255

Abstract: There prevails a widespread notion that, given a closed-loop system, oscillation will commence and build up therein if the magnitude of loop gain is greater than unity at the frequency at which the angle of loop gain is zero degree. Three novel examples in which this notion fails are presented.

Barkhausen criteria

Vimal Singh,

"Failure of Barkhausen oscillation building up criterion:
Further evidence",

Analog Integr. Circ. Sig. Process (Springer 2007),
vol.50, pp.127–132

Abstract: It has been suggested in many textbooks that, given a closed-loop system, oscillation will commence and build up therein if the magnitude of loop gain is greater than unity at the frequency at which the angle of loop gain is zero degree. A novel ideal op-amp based counterexample to this suggestion is presented. The Letter serves to substantiate the findings in a recent Letter. A discussion relating to the finite gain of op-amp is included.

Oscillators are nonlinear circuits.

relaxation versus sinusoidal ;-(

A certain topology may act as a

relaxation oscillator

at low/high frequencies

and as a

sinusoidal oscillator

at high/low frequencies

Oscillators are nonlinear circuits.

Three basic types of oscillators

- 1** Unstable initial dc bias point
Eigenvalues of the linearized Jacobian moving between RHP and LHP
- 2** Stable initial dc bias point
Needs some extra initial energy
The poles are in LHP all the time ???
Special impulse mechanism is needed
- 3** Combination of 1 and 2
Poles are moving around in LHP only

1 Colpitts Oscillator Family

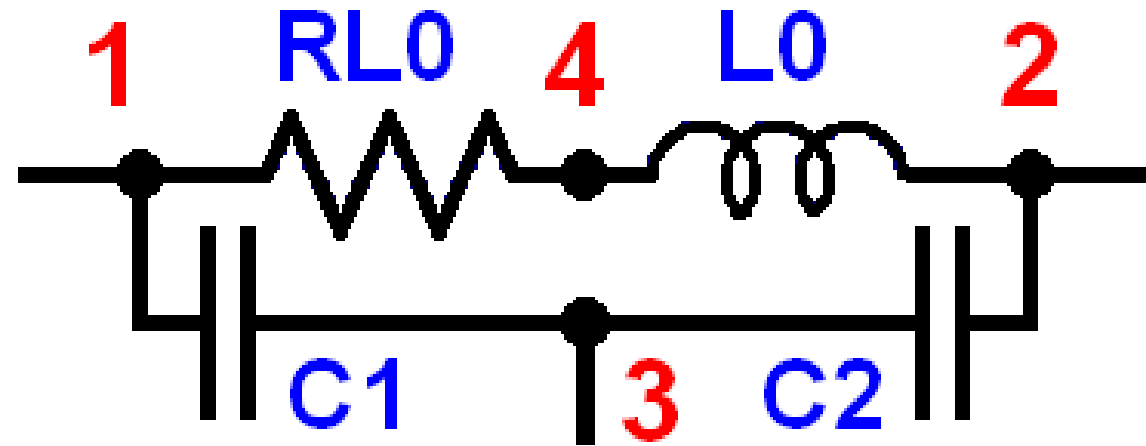
2 Amplifiers and Oscillators

3 Colpitts Oscillators based on Transistors

4 Colpitts Oscillators based on Amplifiers

5 Conclusion

COLPITTS RESONATOR



```
.subckt colpitts 1 2 3
```

```
* colpitts resonator
```

100kHz

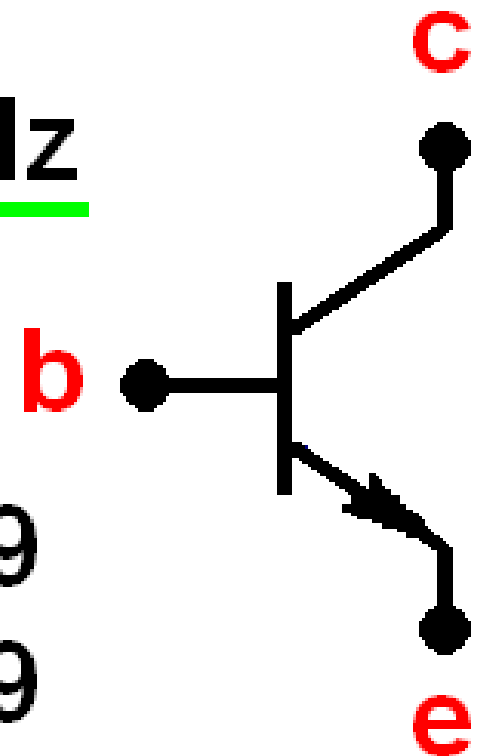
```
RL0 1 4 50
```

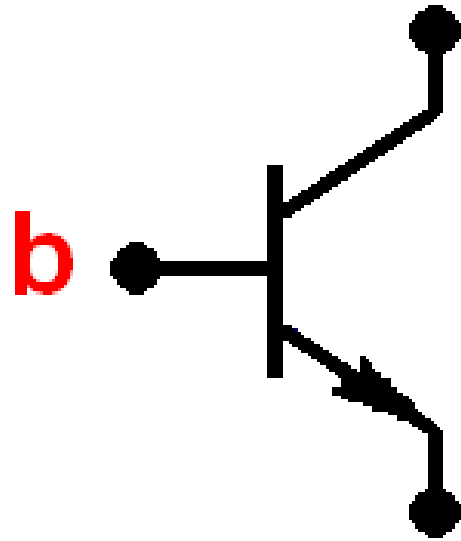
```
L0 4 2 1e-3
```

```
C1 1 3 4.812756223e-09
```

```
C2 2 3 5.347506914e-09
```

```
.ends
```

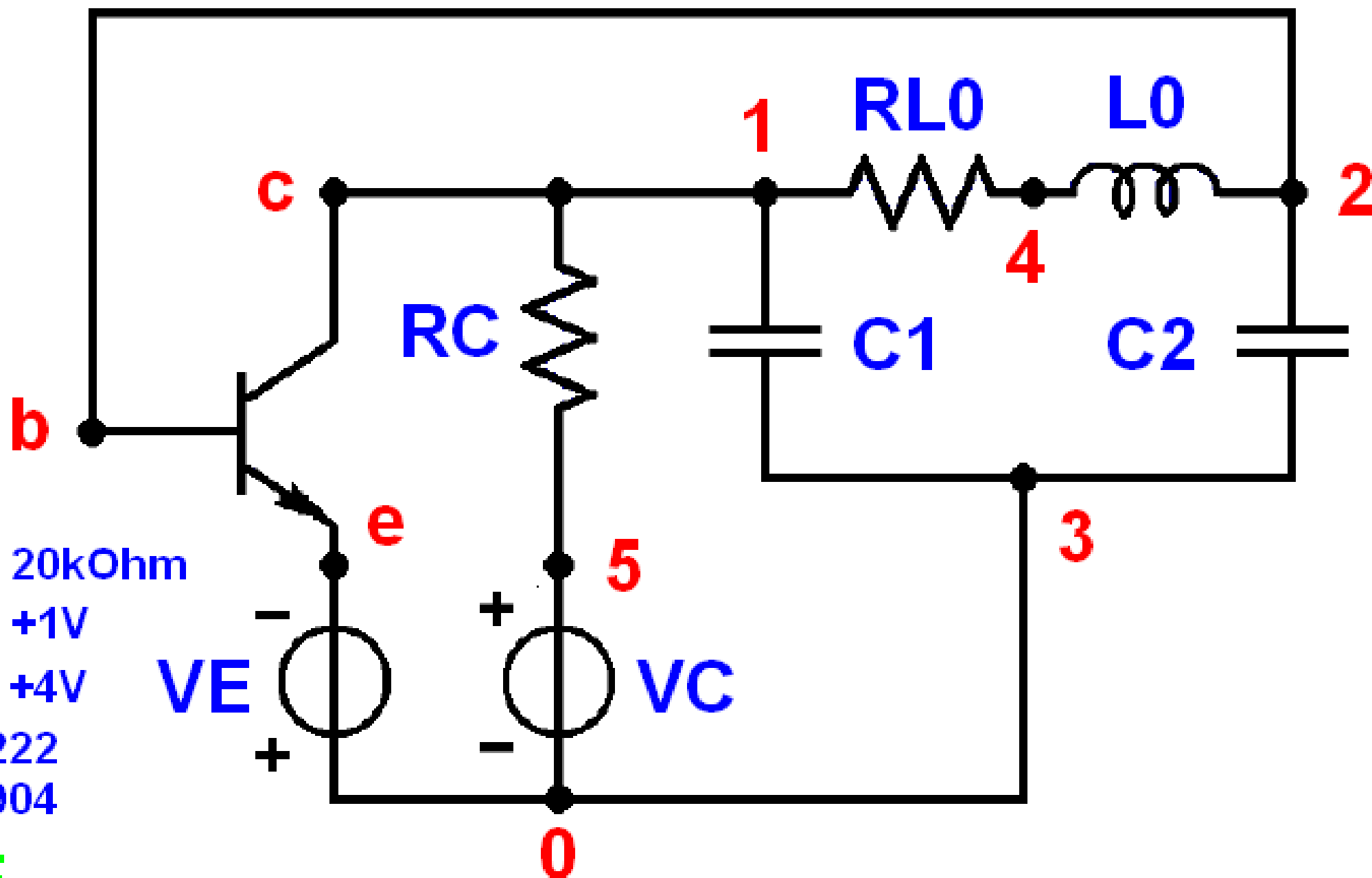


Case:	CE			CB			CC		
QNPN	e	c	b	b	e	c	c	b	e
	1	2	3	1	2	3	1	2	3
	2	3	1	2	3	1	2	3	1
	3	1	2	3	1	2	3	1	2
	1	3	2	1	3	2	1	3	2
	3	2	1	3	2	1	3	2	1
	2	1	3	2	1	3	2	1	3

CCCS

18 patterns

6 ss osc



$R_C = 20\text{k}\Omega$

$V_E = +1\text{V}$

$V_C = +4\text{V}$

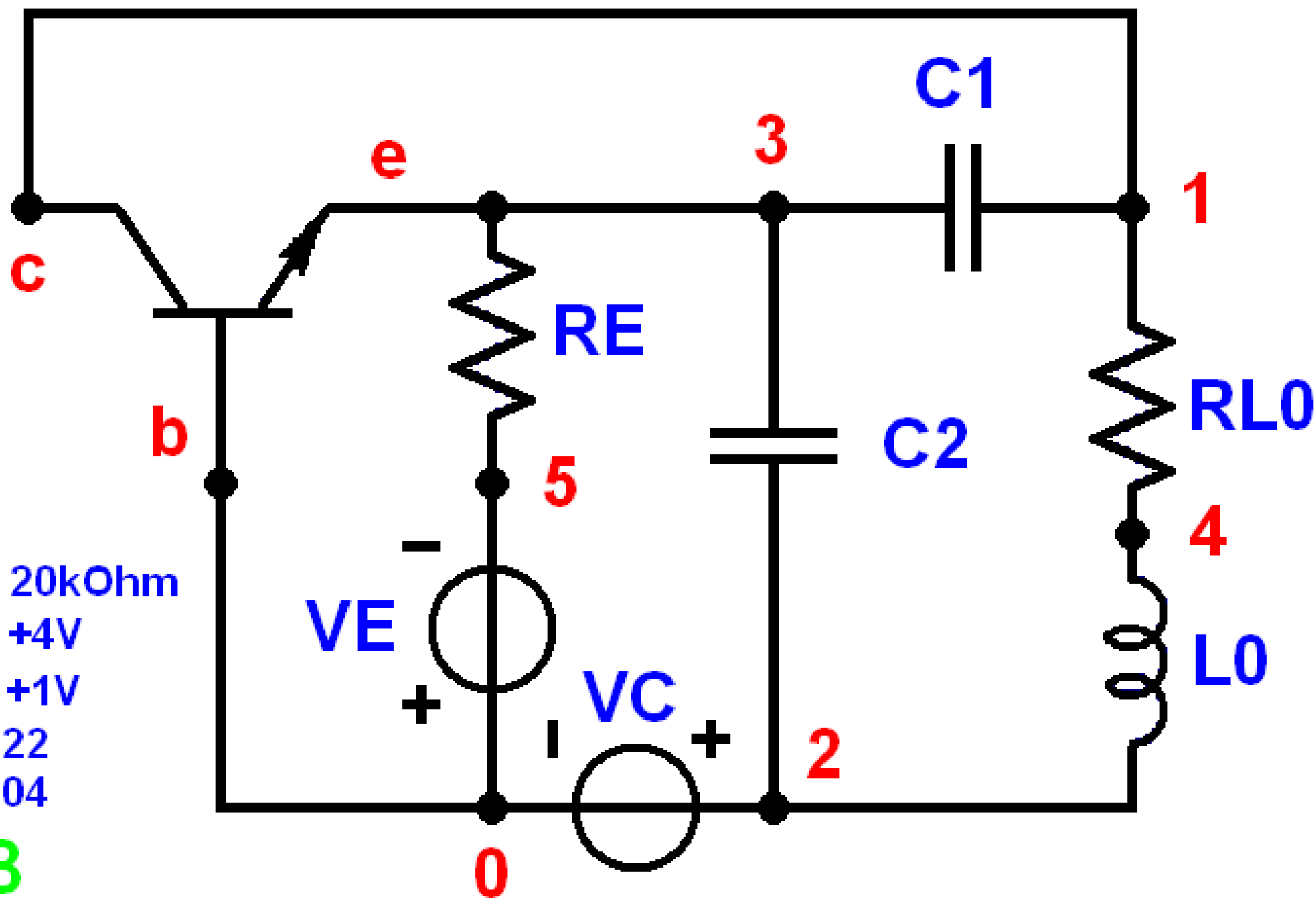
2N2222

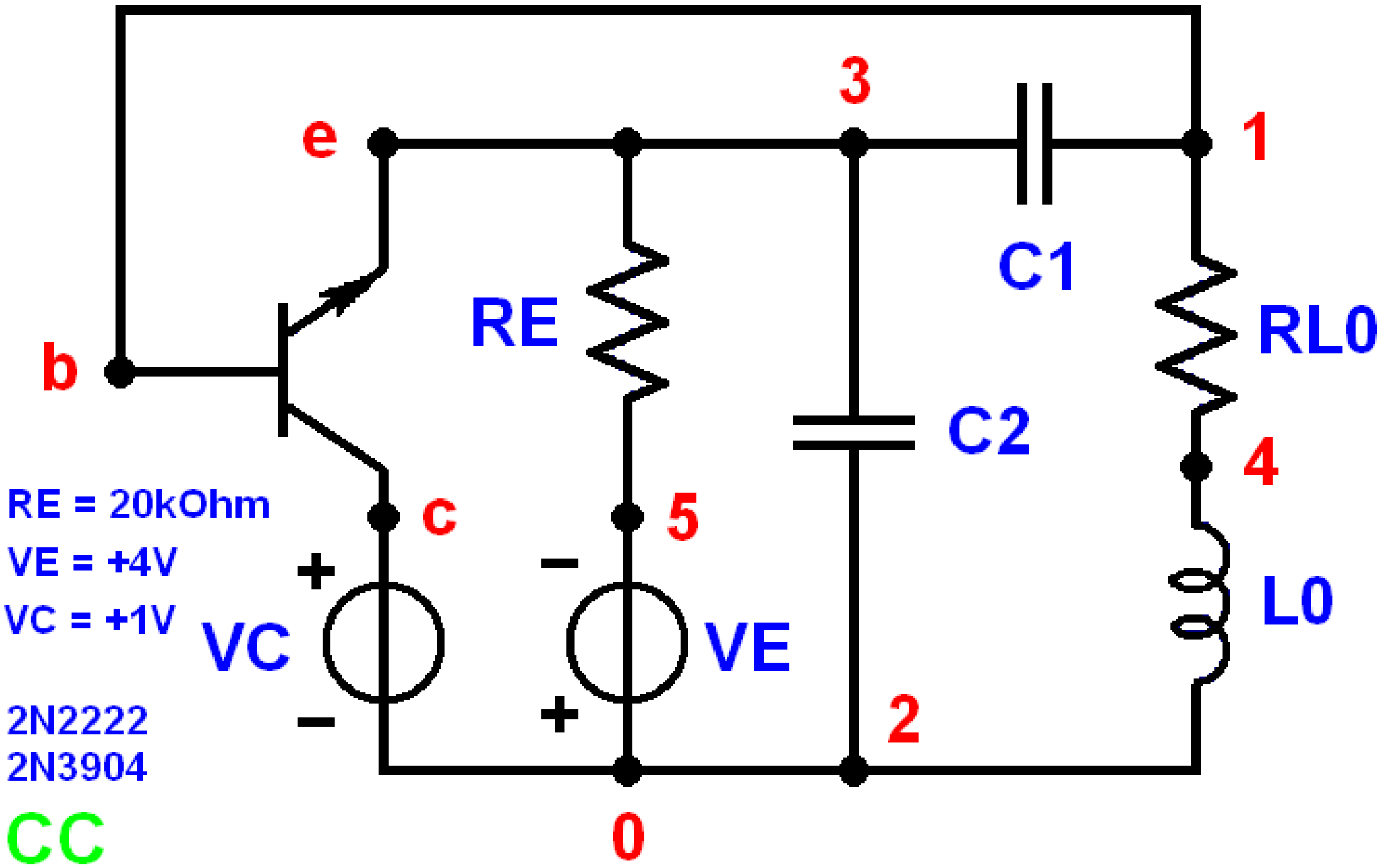
2N3904

CE

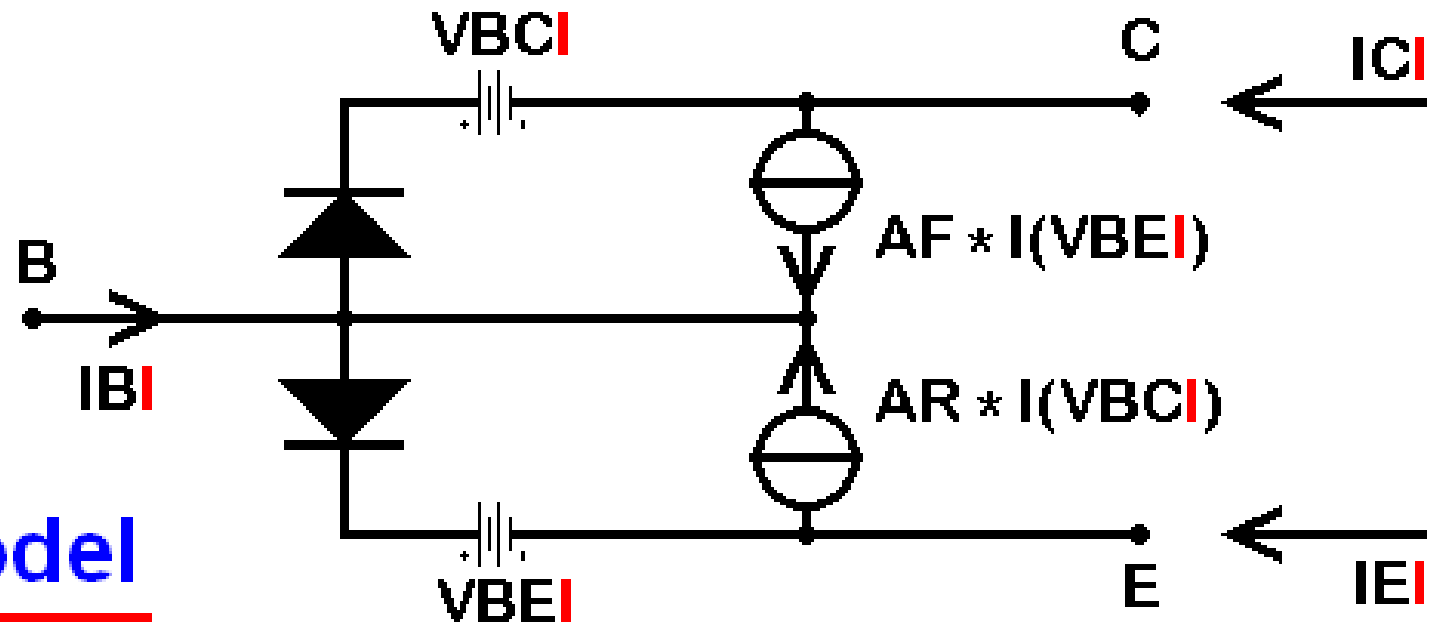
$R_E = 20\text{k}\Omega$
 $V_E = +4\text{V}$
 $V_C = +1\text{V}$
2N2222
2N3904

CB

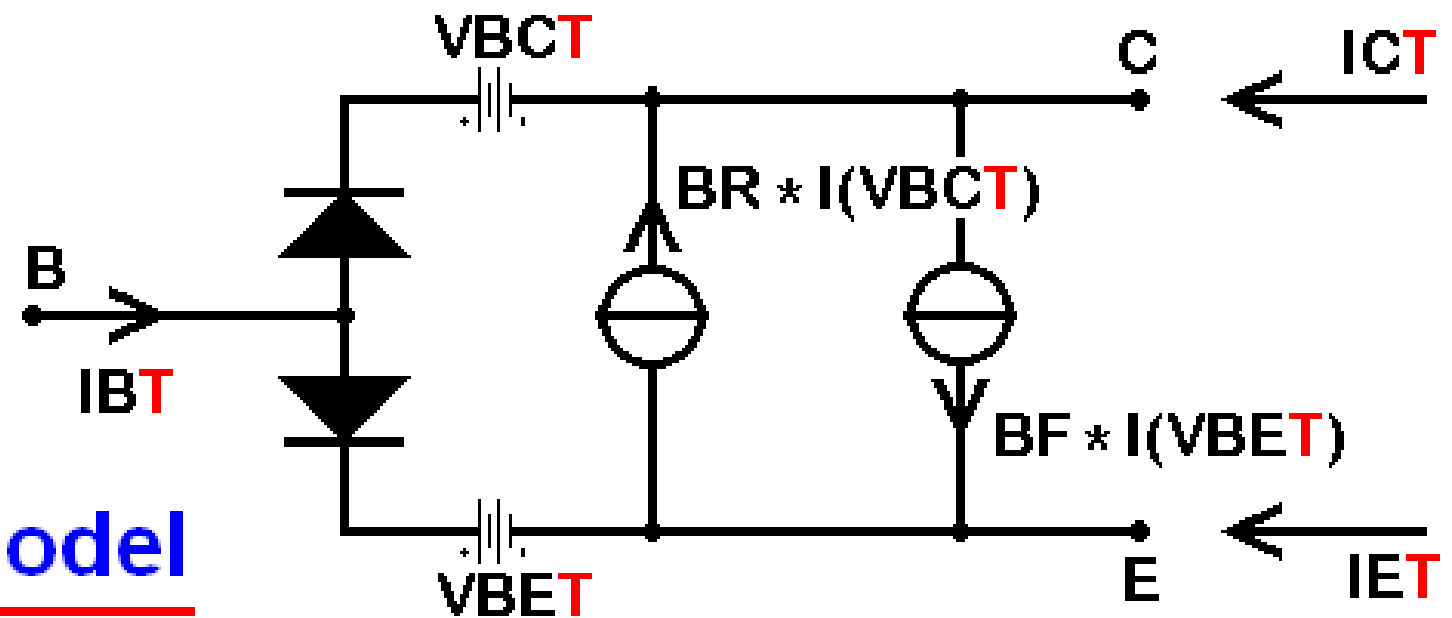




Ebers-Moll Injection Model



Ebers-Moll Transport Model



Ebers-Moll Injection Model

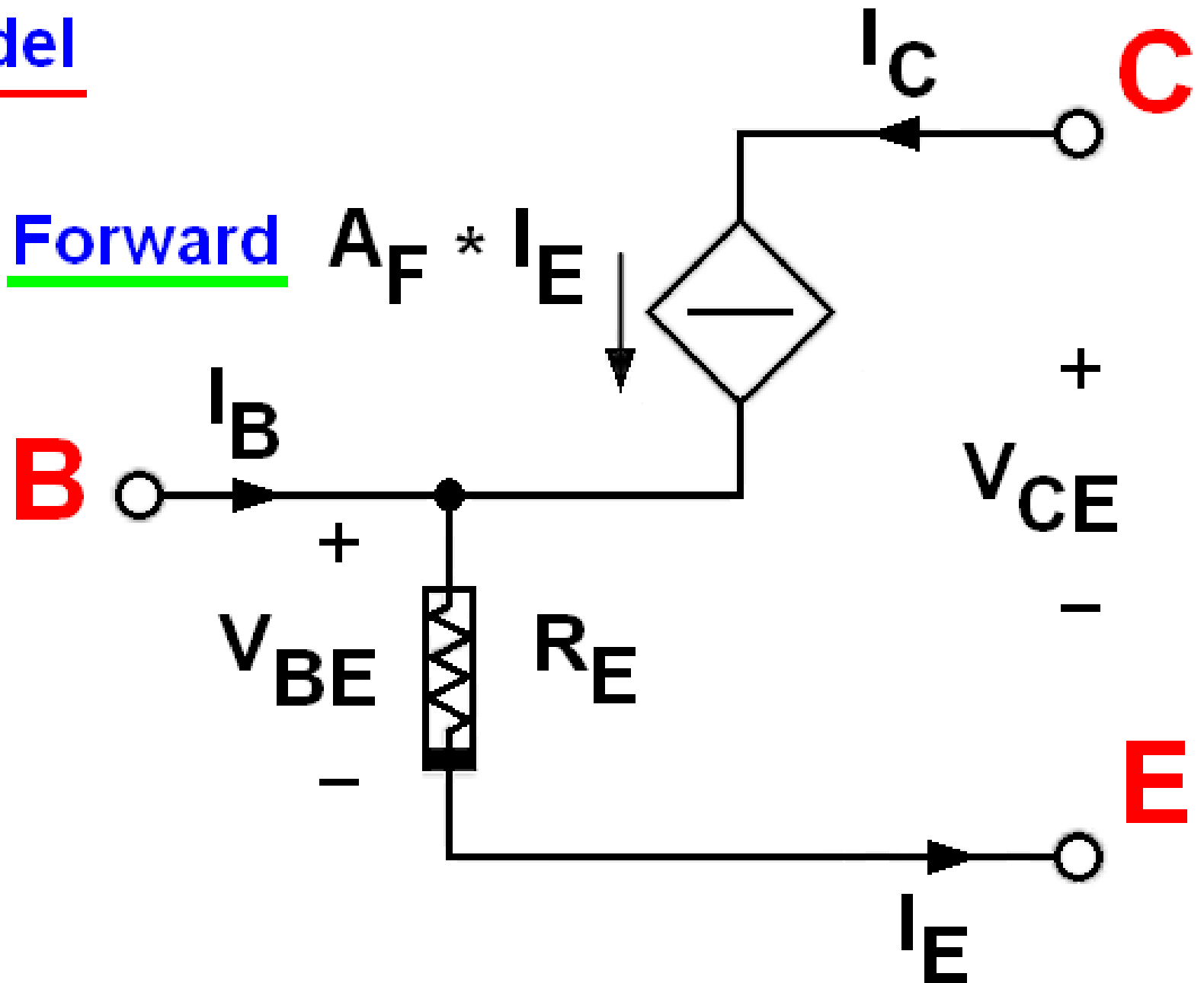
$$A_F = 0.9976$$

Forward $A_F * I_E$

$$B_F = 415.67$$

$$A_F = \frac{B_F}{B_F + 1}$$

$$B_F = \frac{A_F}{1 - A_F}$$



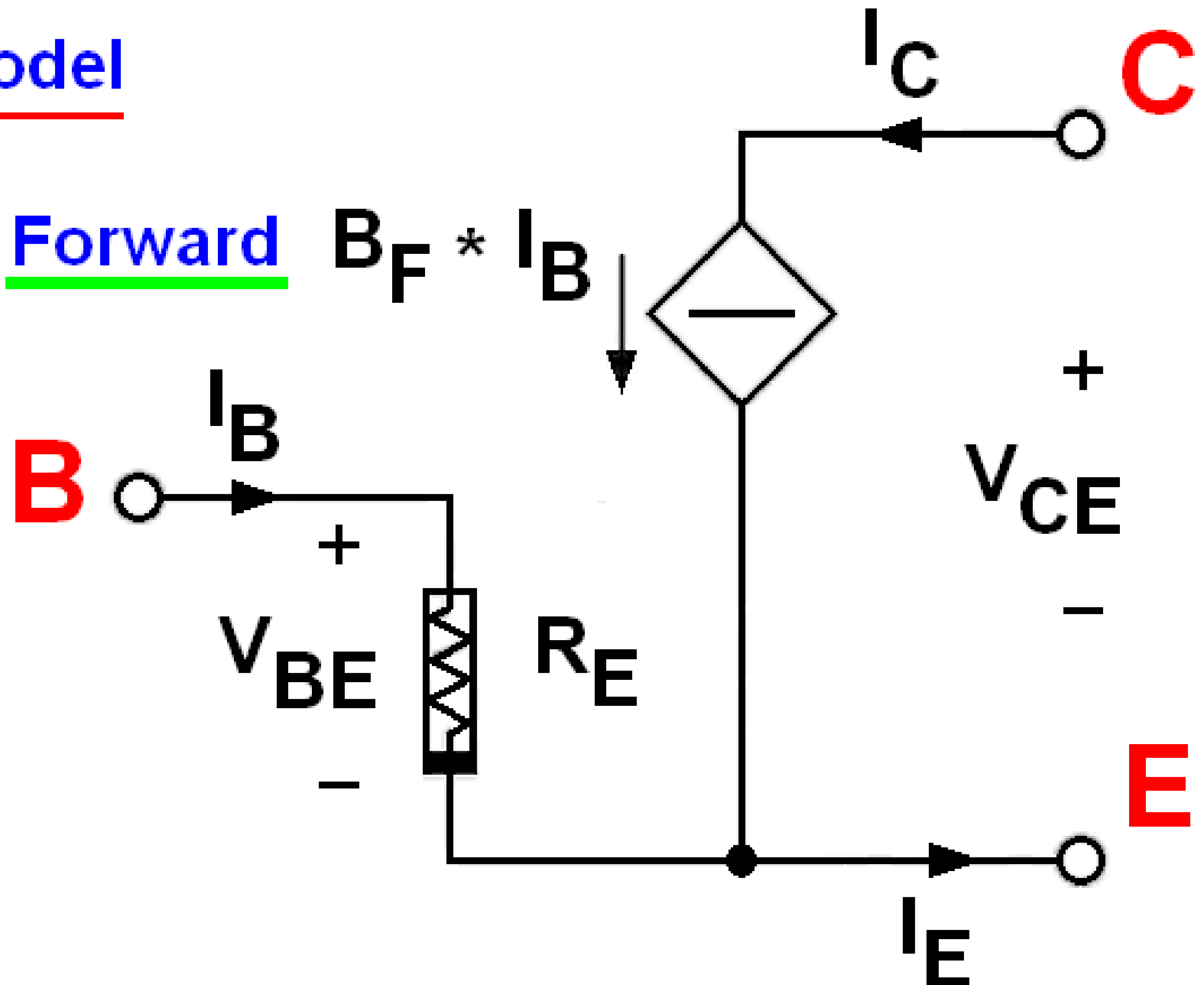
Ebers-Moll Transport Model

$$B_F = 415.67 \quad \text{Forward} \quad B_F * I_B$$

$$A_F = 0.9976$$

$$B_F = \frac{A_F}{1 - A_F}$$

$$A_F = \frac{B_F}{B_F + 1}$$



Frozen eigenvalue approach

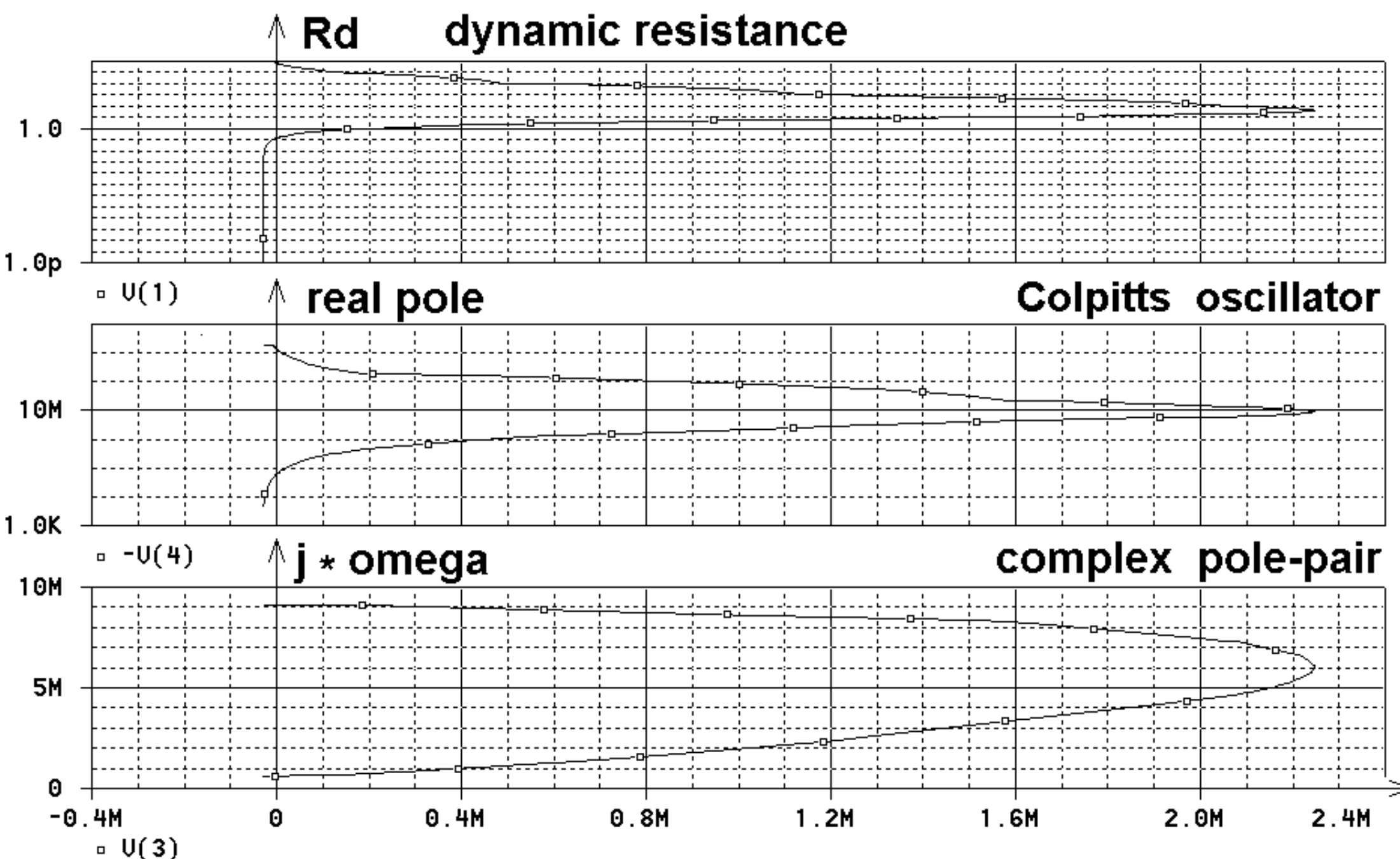
Eigenvalues of linearized Jacobian
of differential equations

Only one non-linearity: Base-Emitter Diode

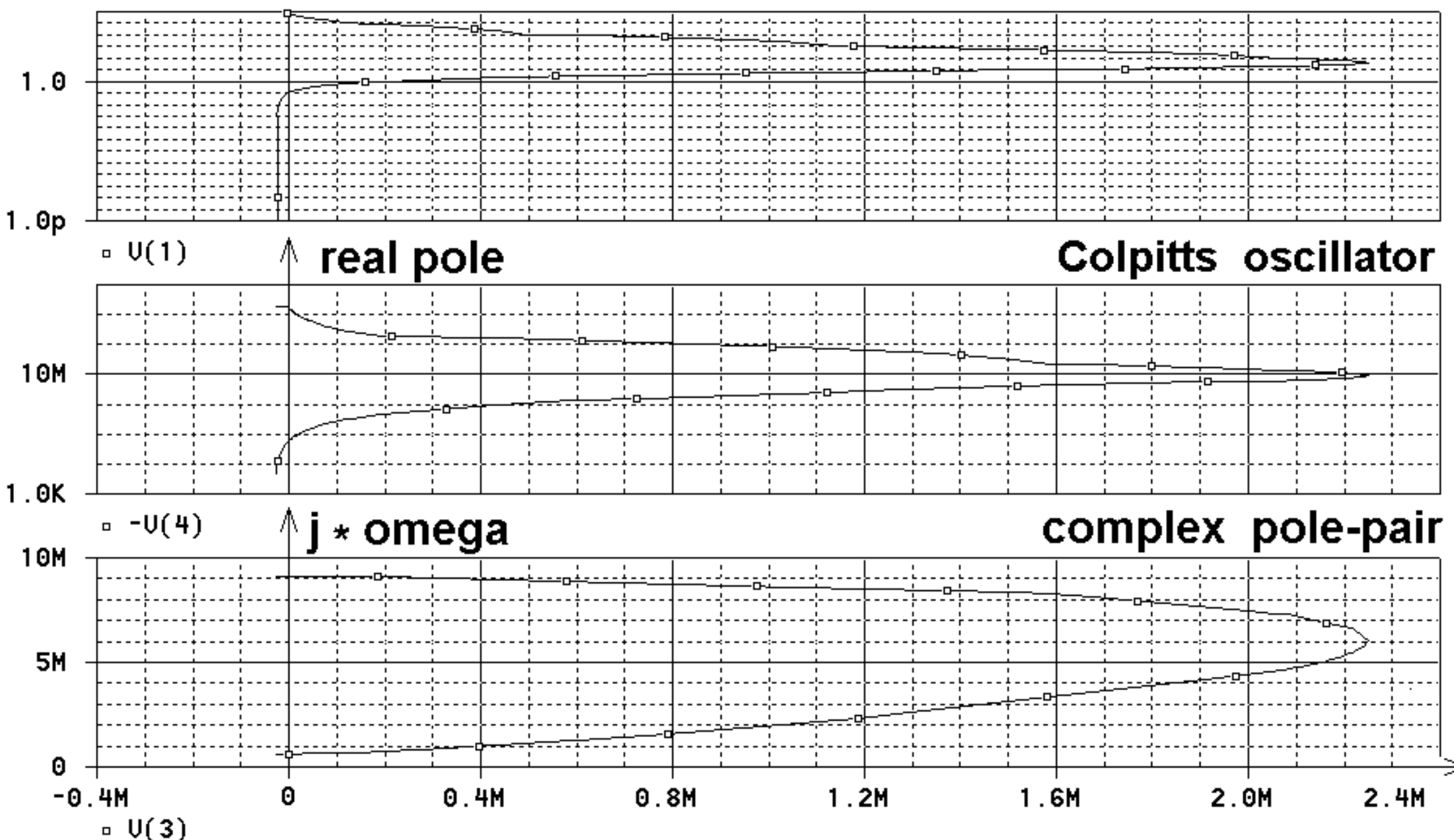
Dynamic resistance R_d

ANP3

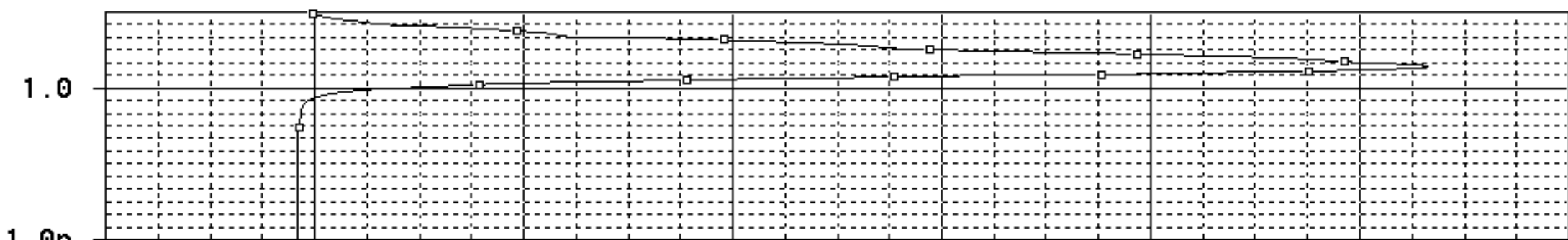
Trajectories of poles in the
complex frequency plane



CE



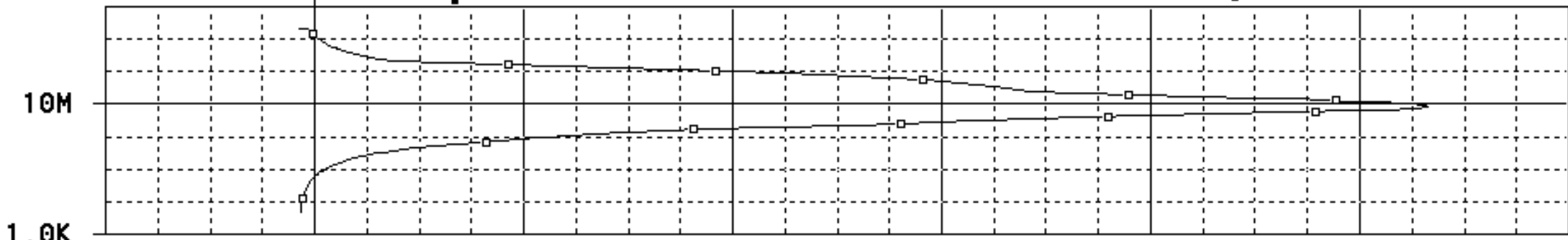
CB complex pole-pair trajectory sigma



□ U(1)

real pole

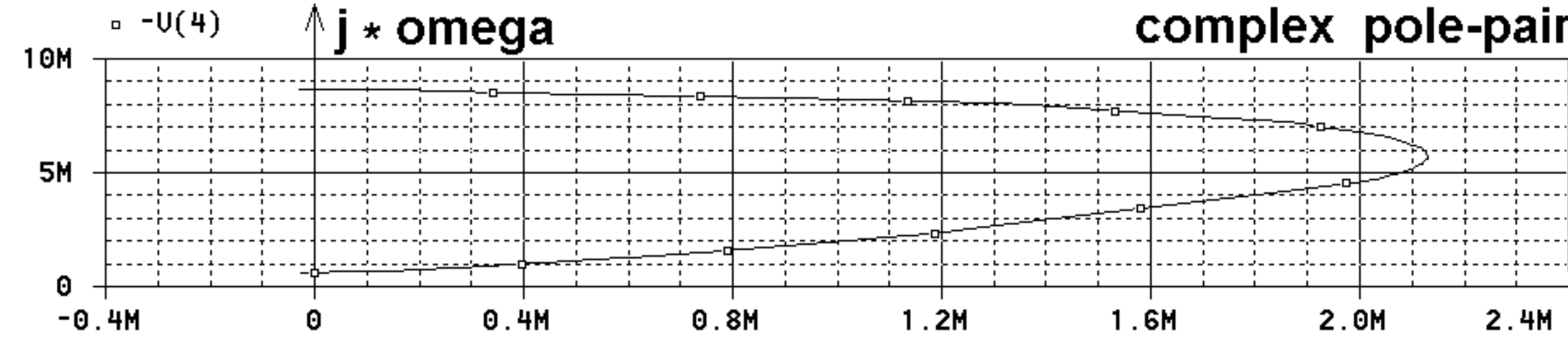
Colpitts oscillator



□ -U(4)

$j * \omega$

complex pole-pair



□ U(3)

complex pole-pair trajectory

sigma

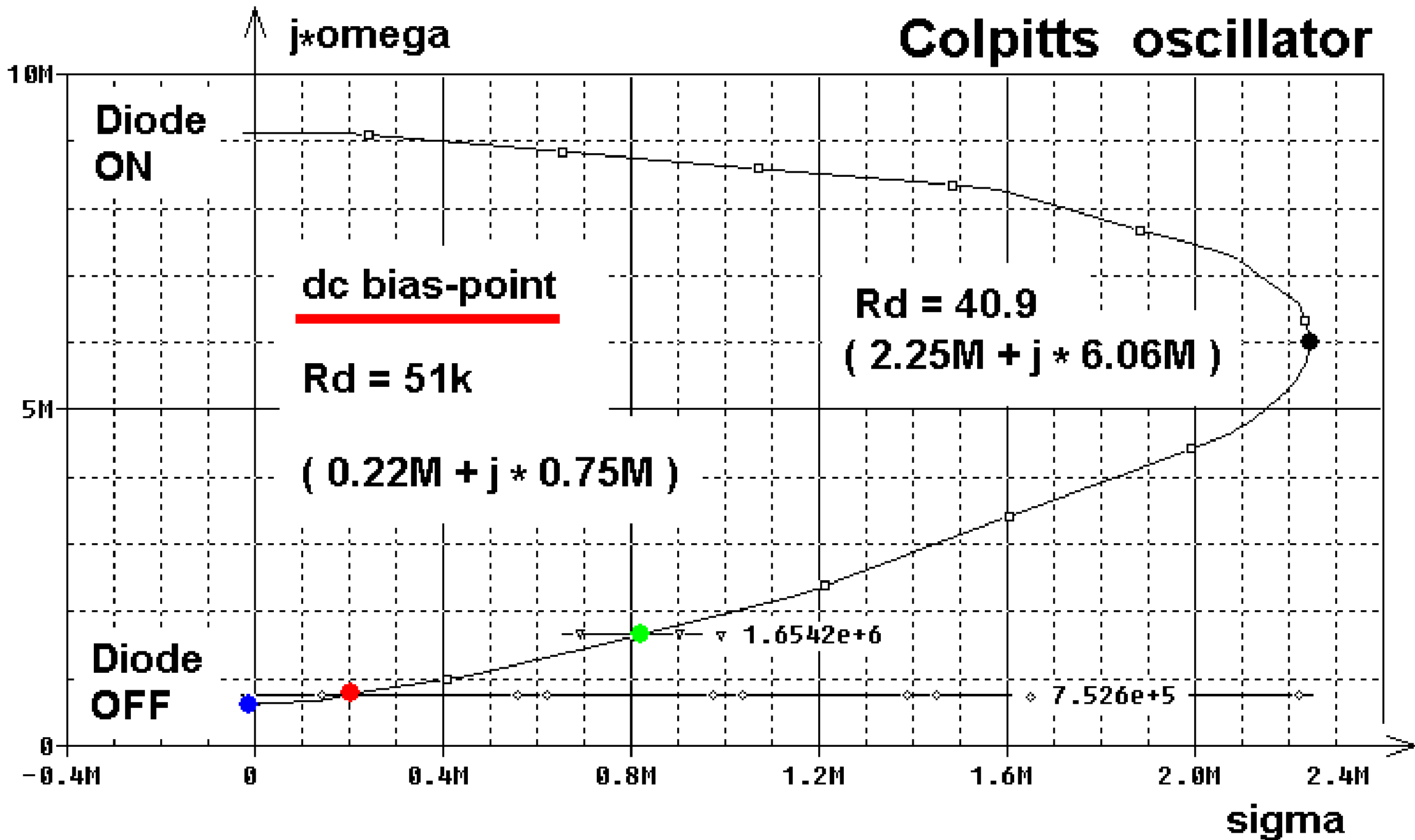
CC

CE Colpitts Oscillator

	<u>Rd</u>	sigma j*omega		real-p
OFF	1e+12	-0.03M	0.63M	-4.92k
dc bias	51k	+0.22M	0.75M	-0.50M
ON	2.5k	+0.84M	1.65M	-1.81M

Frozen eigenvalues as function of
dynamic resistance Rd of base-emitter diode

Colpitts oscillator



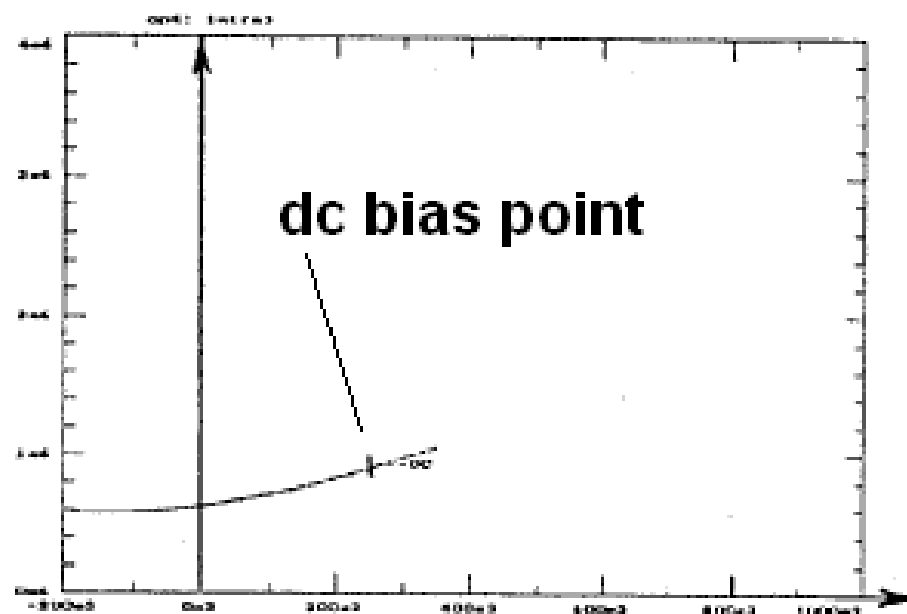


Figure 7: x-axis: real part, y-axis: positive imaginary part of complex pole pair.
First order limit cycle case.

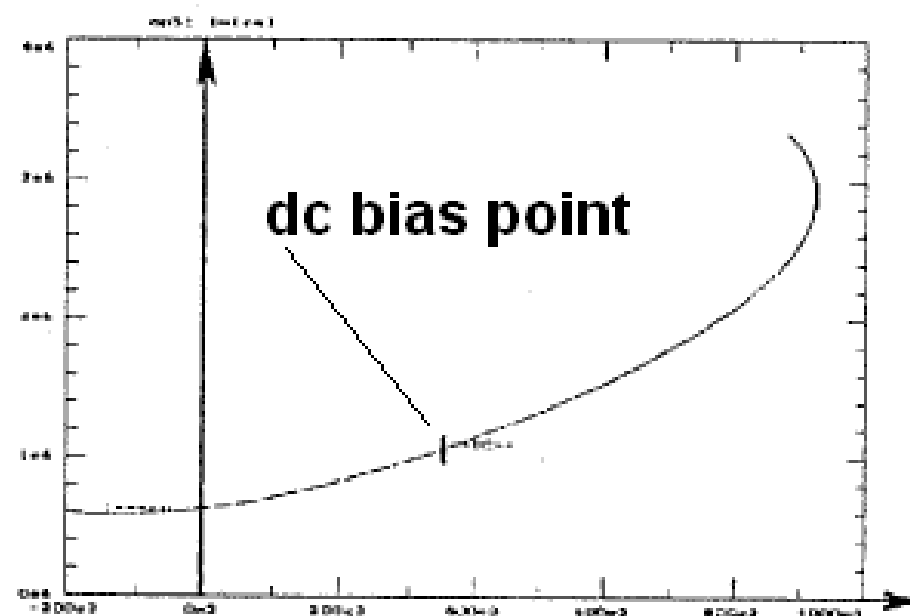


Figure 8: x-axis: real part, y-axis: positive imaginary part of complex pole pair.
Chaotic "limit cycle" case.

Erik Lindberg,
"Colpitts, Eigenvalues and Chaos"
Proceedings 5'th International Specialist Workshop,
Nonlinear Dynamics of Electronic Systems,
NDES'97, June 26-27 1997 Moscow Russia, pp 262-267.

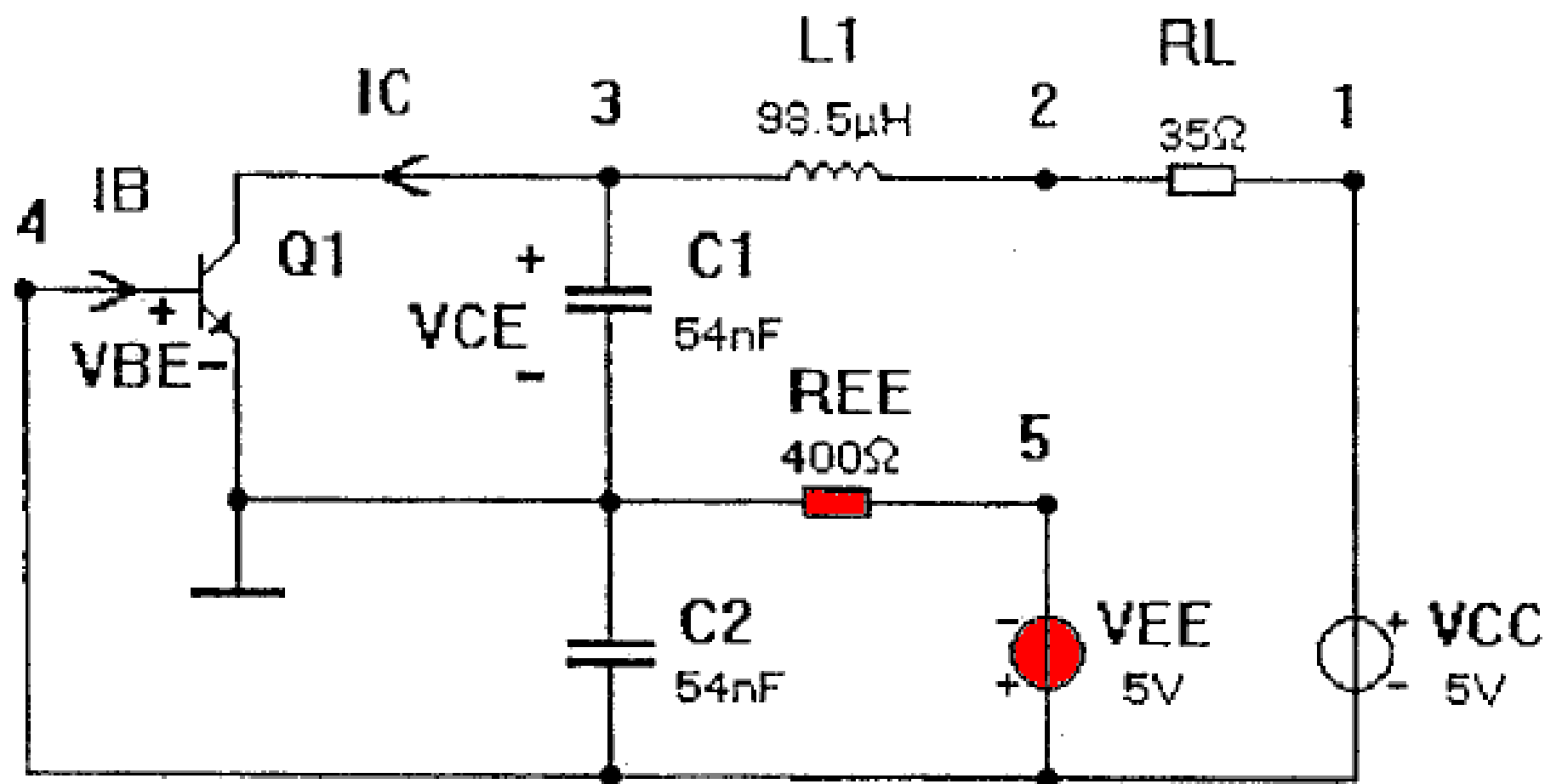
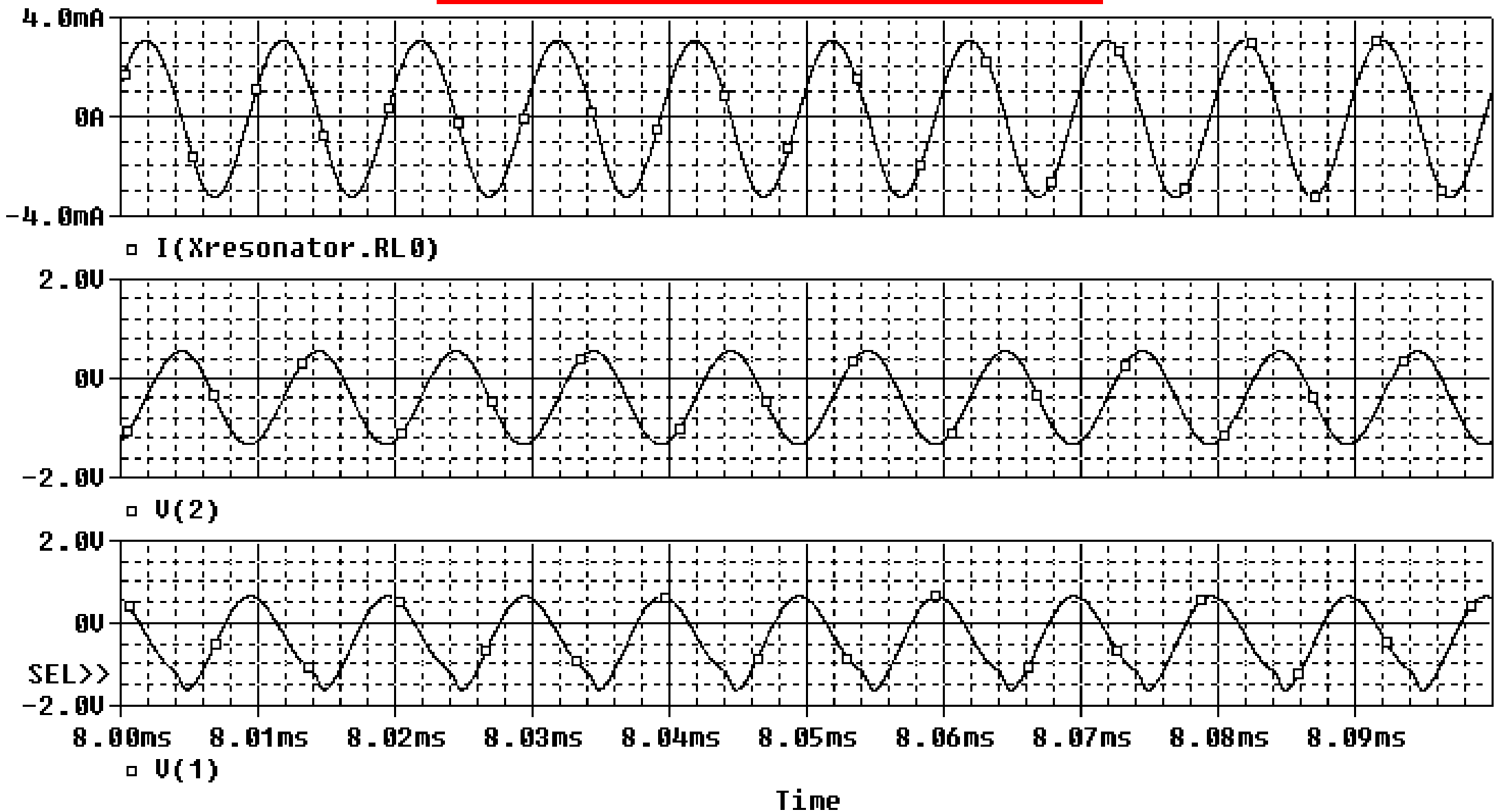


Figure 1: Colpitts oscillator.

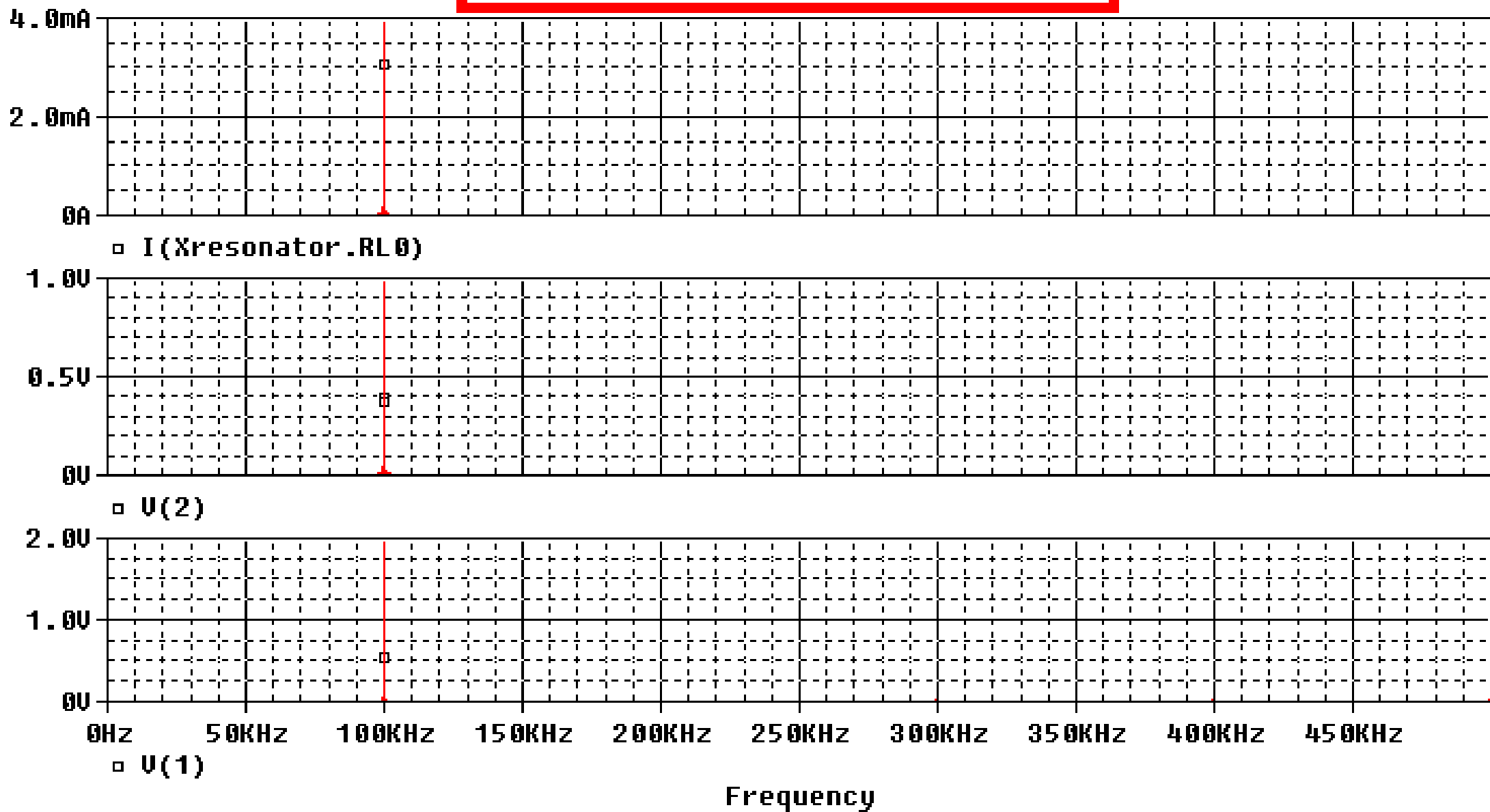
Colpitts Oscillator



CE **FFT**

time: 0.5ms - 10.0ms

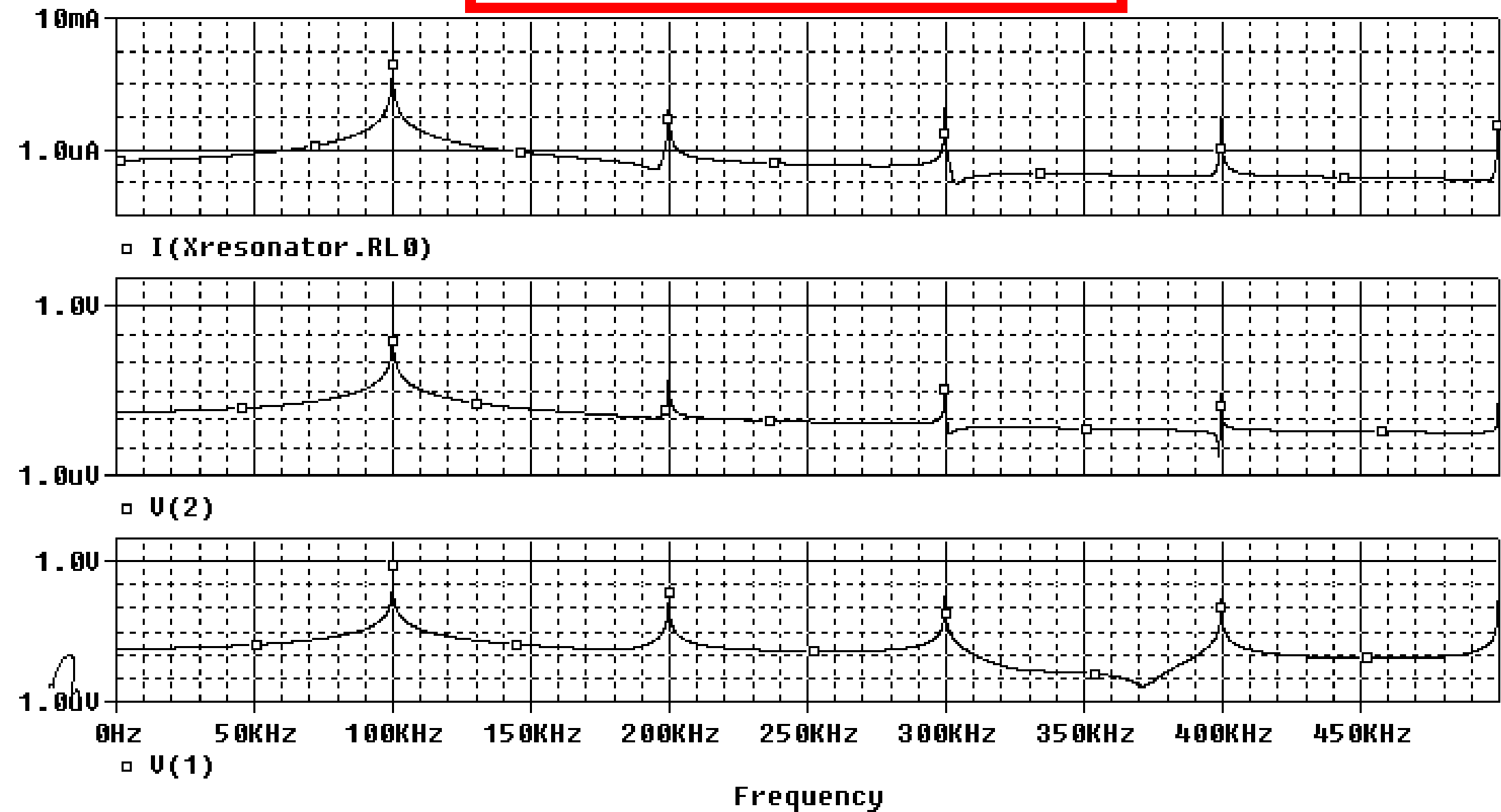
Colpitts Oscillator



CE FFT

time: 0.5ms - 10.0ms

Colpitts Oscillator



CE **FFT**

time: 0.5ms - 10.0ms

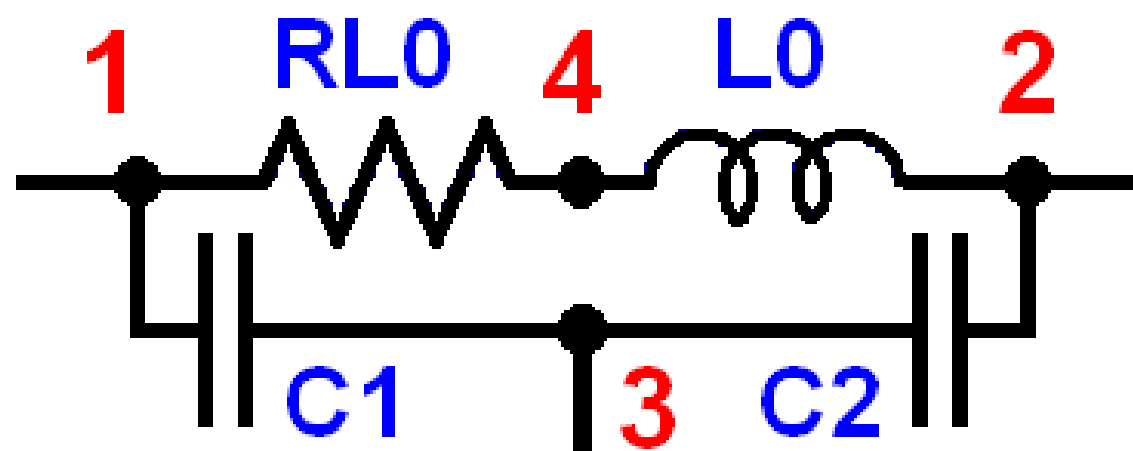
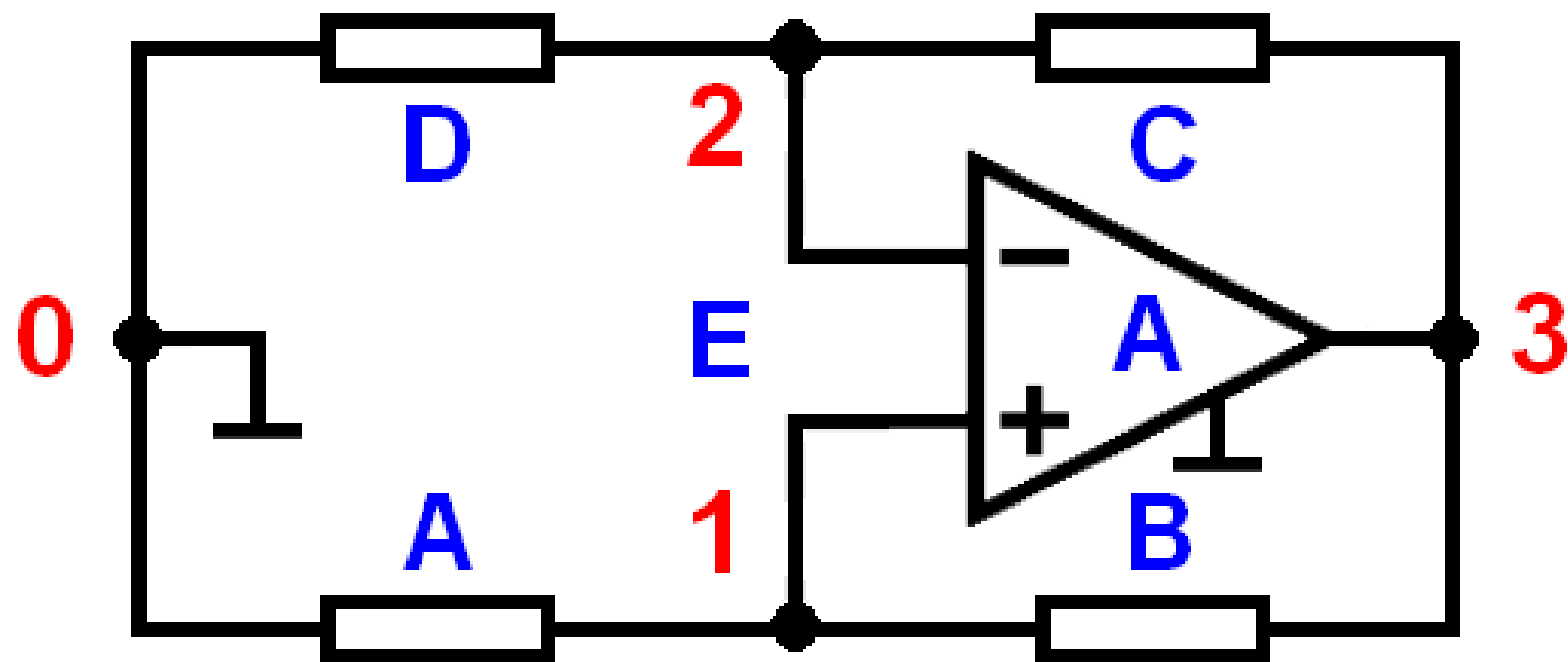
1 Colpitts Oscillator Family

2 Amplifiers and Oscillators

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4 Colpitts Oscillators based on Amplifiers

5 Conclusion



Case:

B

C

E

AMP

1 3 0

2 3 0

2 1 0

VCVS

1 2 3

1 2 3

1 2 3

Case B2

2 3 1

2 3 1

2 3 1

3 1 2

3 1 2

3 1 2

1 3 2

1 3 2

1 3 2

3 2 1

3 2 1

3 2 1

2 1 3

2 1 3

2 1 3

Case E6

18 patterns

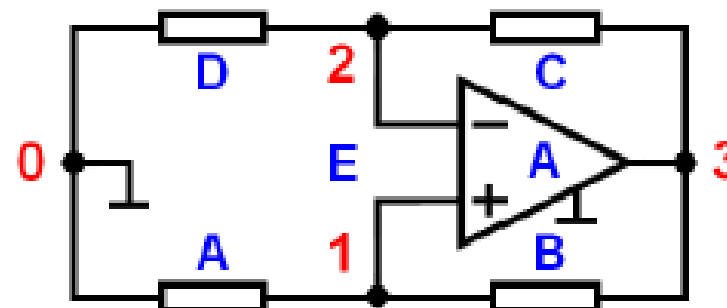
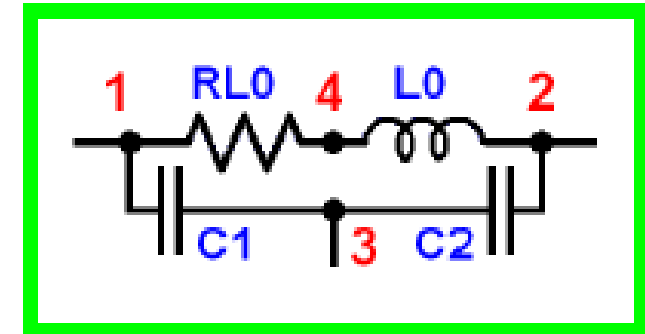
7 ss osc

Case B2

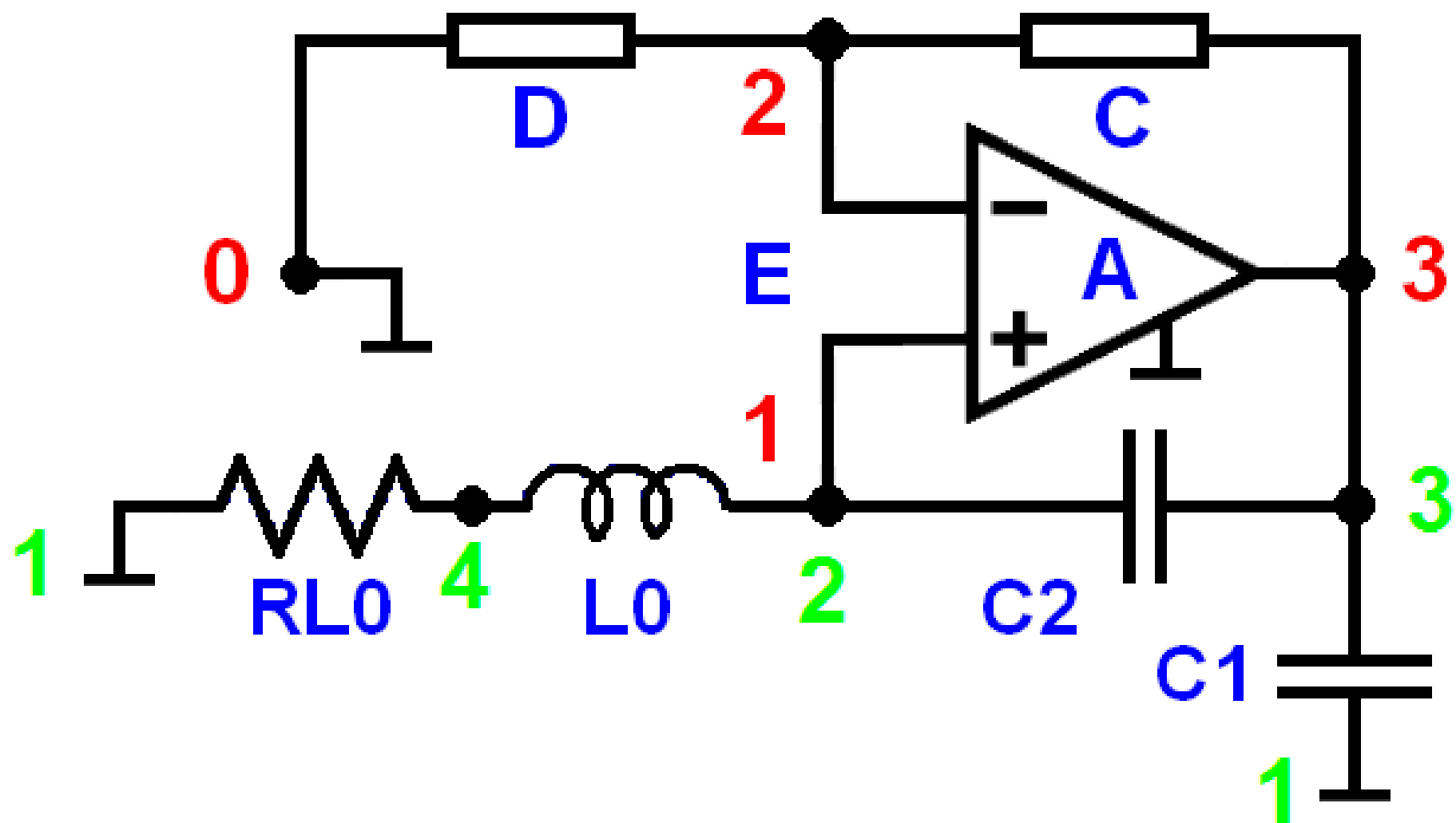
```

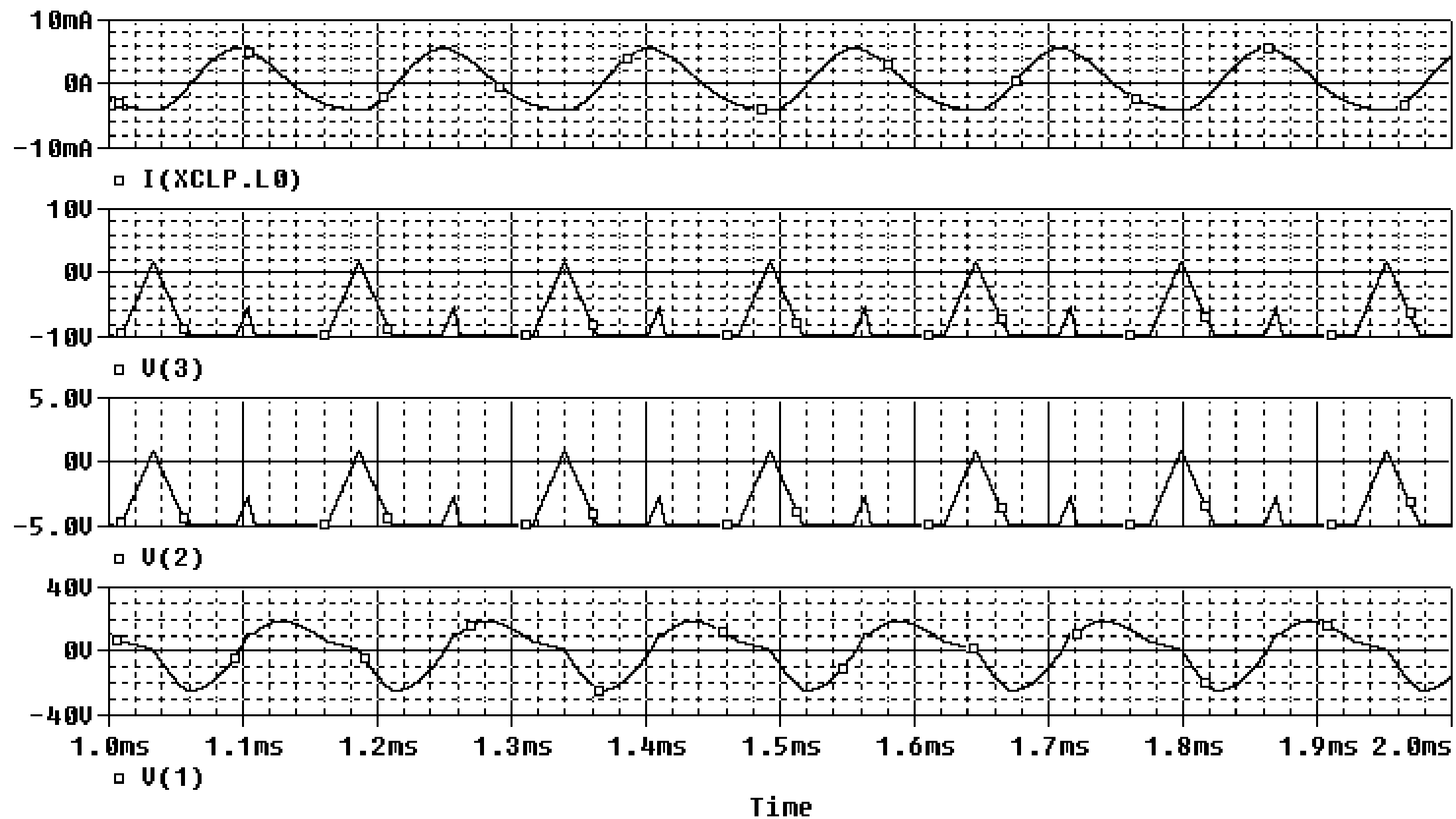
* case B  1  2  3
*  XCLP   1  3  0  colpitts  ; no osc
*  XCLP   0  1  3  colpitts  ; ss osc
*  XCLP   3  0  1  colpitts  ; no osc
*
*
*  XCLP   1  0  3  colpitts  ; ss osc
*  XCLP   0  3  1  colpitts  ; no osc
*  XCLP   3  1  0  colpitts  ; damp osc
*
*
*  RA      1  0      800
*  RB      1  3      800
*  RC      2  3      800
*  RD      2  0      800

```



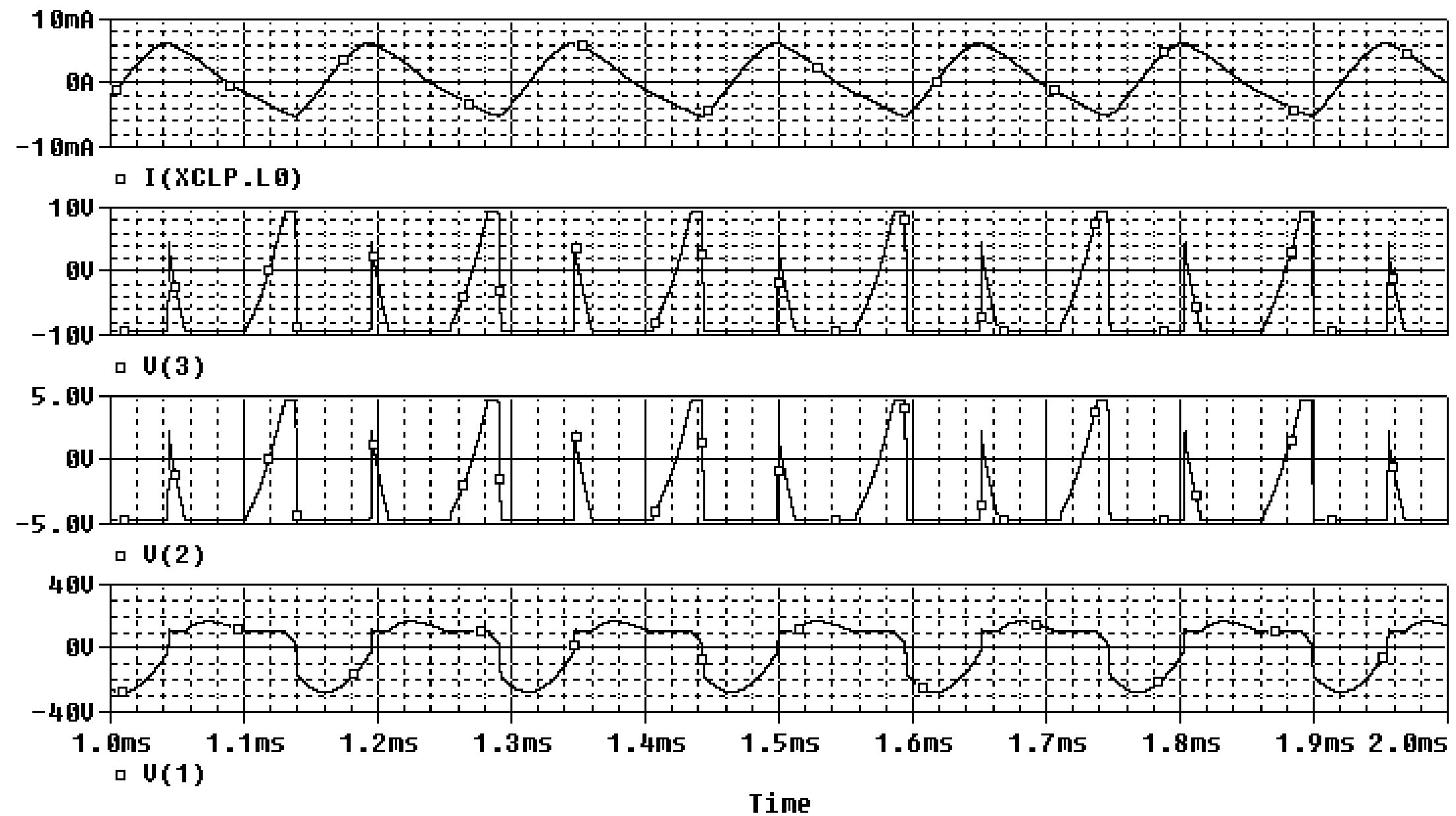
Case B2





XOPAMP: uA741

Case B2



XOPAMP: TL082

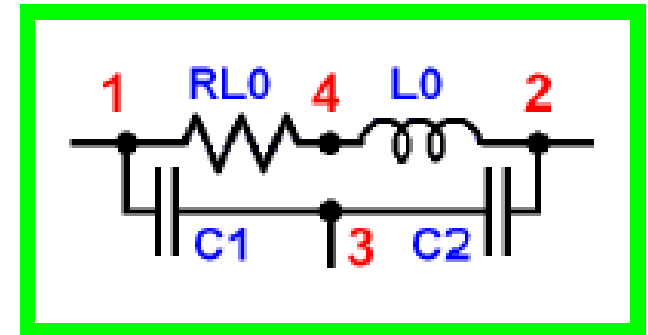
Case B2

Case E6

```

* case E  1 2 3
* XCLP  2 1 0 colpitts ; conv. problems
* XCLP  0 2 1 colpitts ; no osc
* XCLP  1 0 2 colpitts ; ss osc
*
* XCLP  2 0 1 colpitts ; no osc
* XCLP  0 1 2 colpitts ; ss osc
* XCLP  1 2 0 colpitts ; ss osc

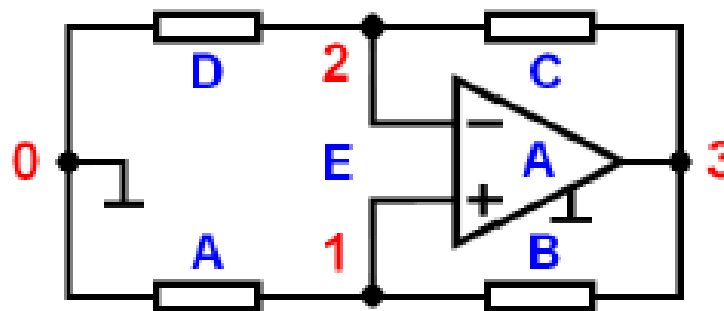
```



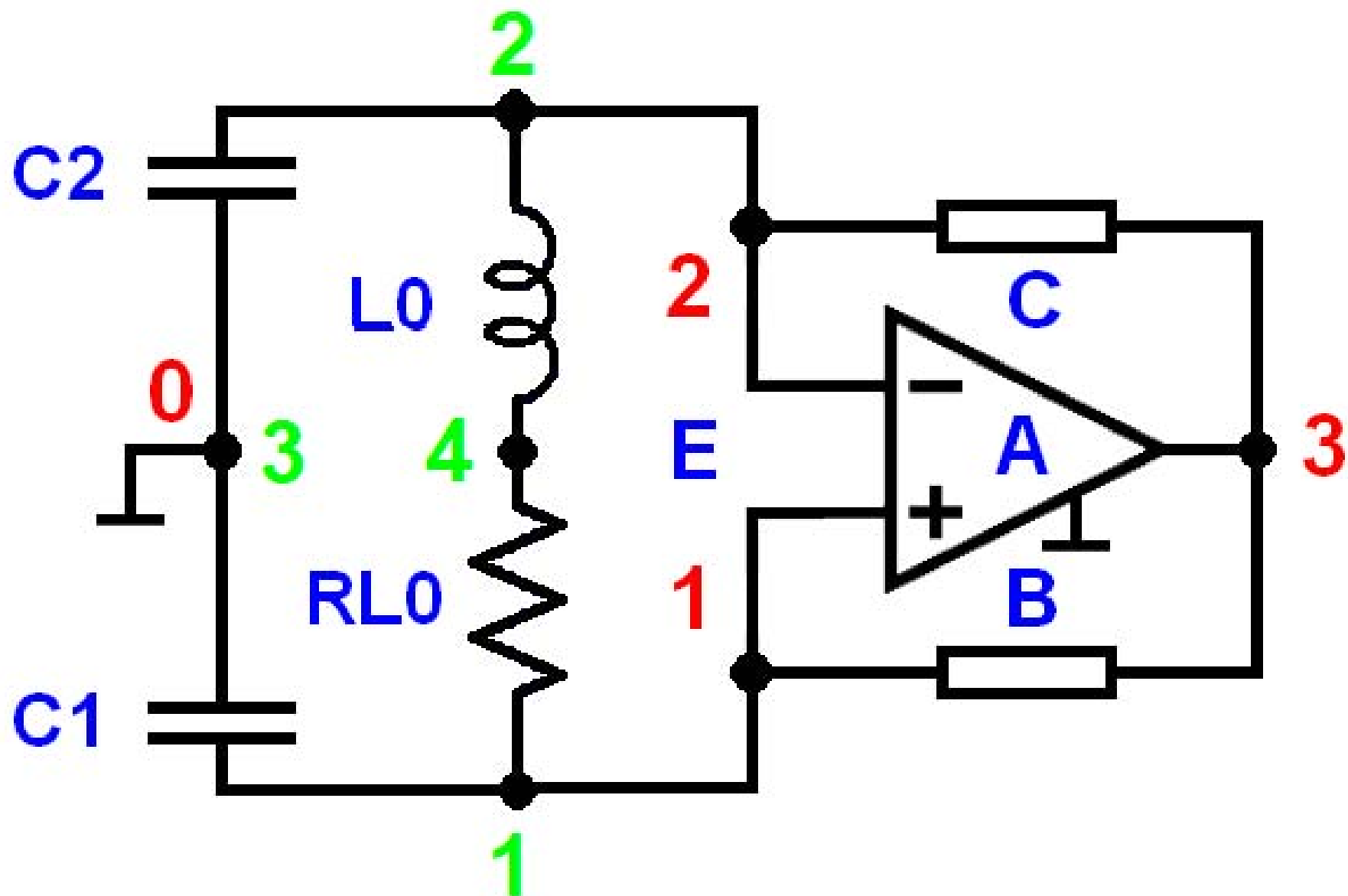
```

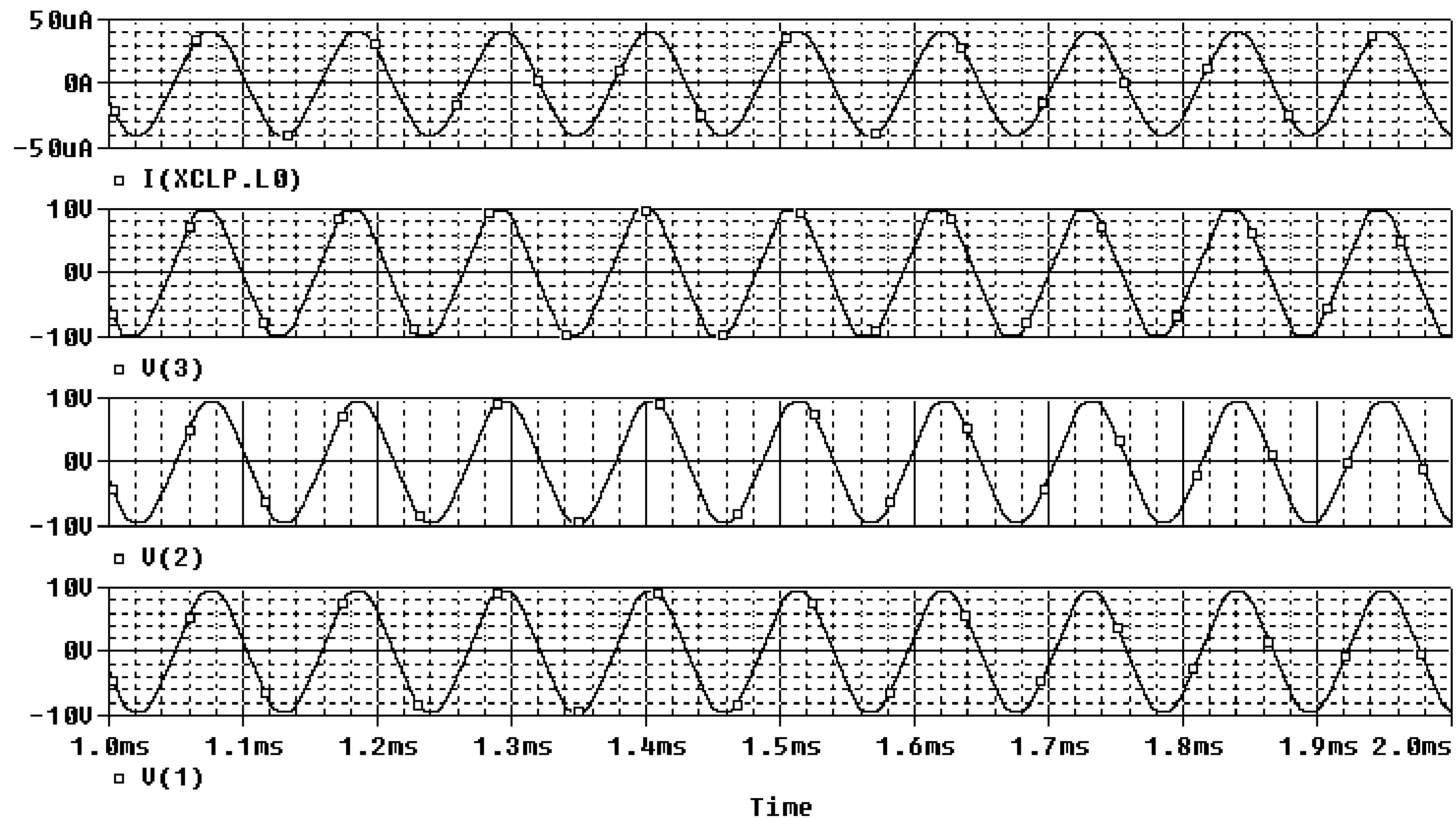
* RA  1 0 800
* RB  1 3 800
* RC  2 3 800
* RD  2 0 800

```



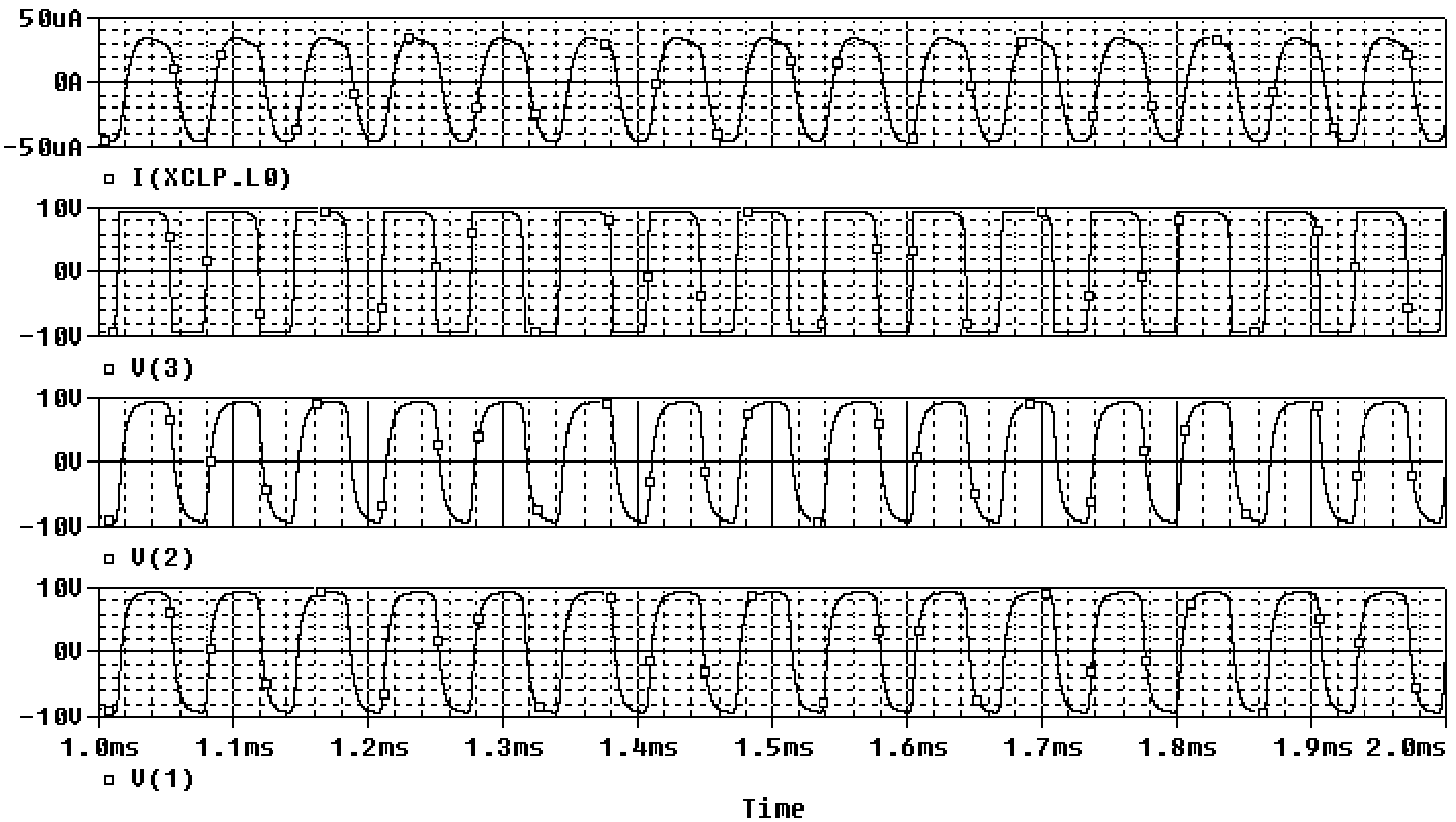
Case E6





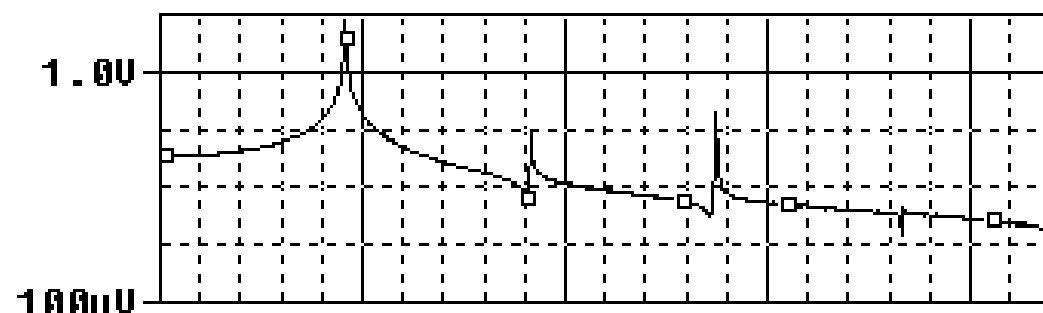
XOPAMP: $\mu A741$

Case E6

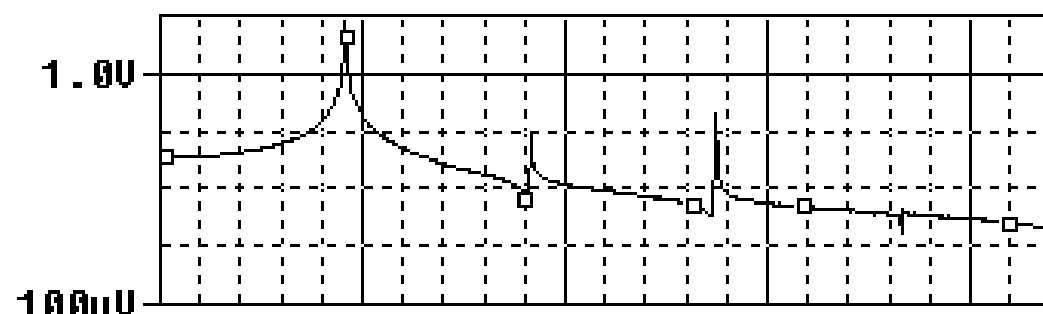


XOPAMP: TL082

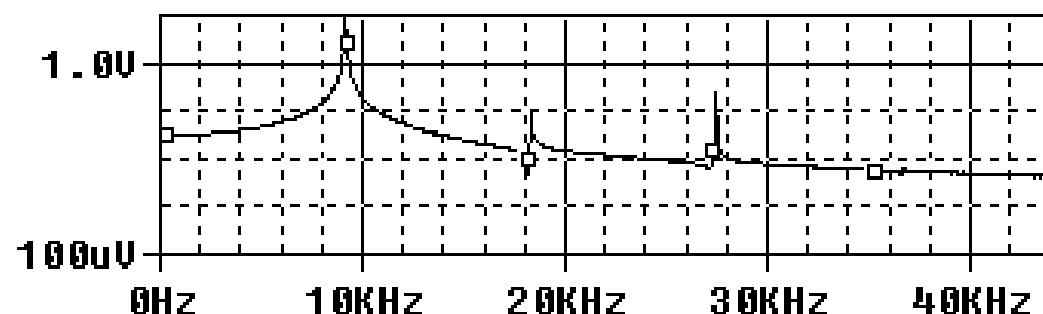
Case E6



□ V(2)



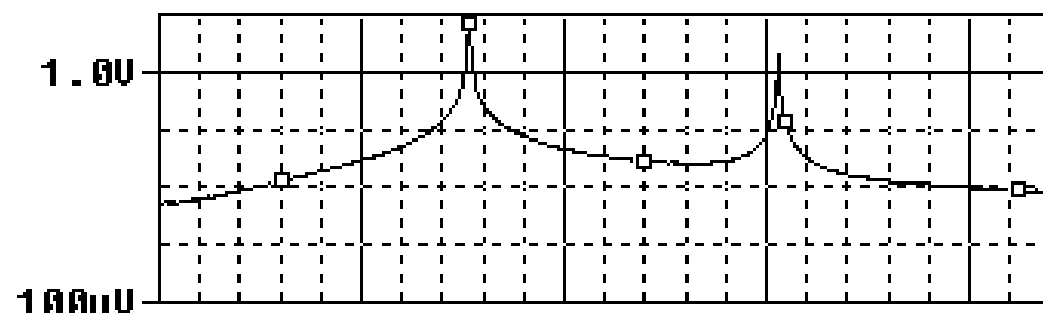
□ V(1)



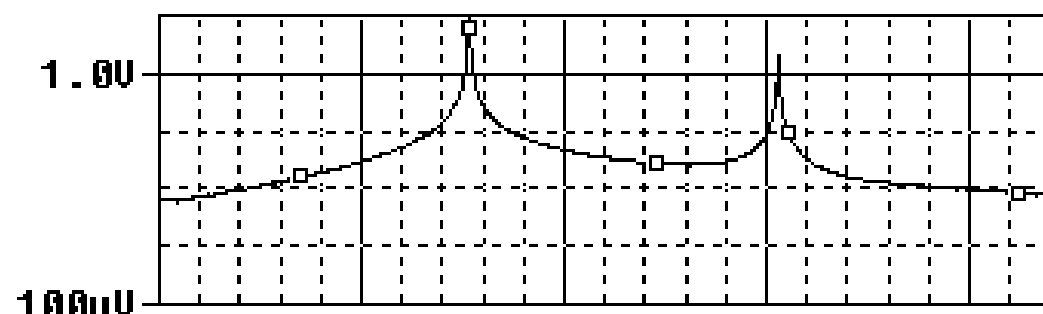
□ V(3)

ua741

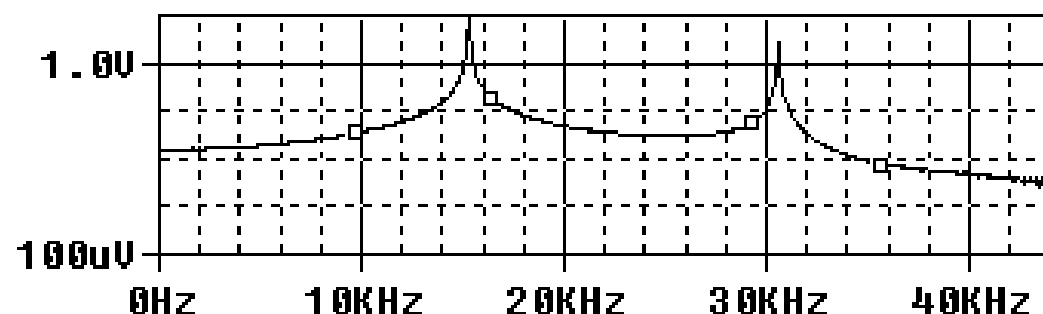
Case E6



□ V(2)

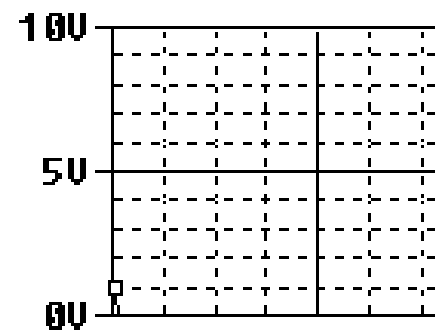


□ V(1)

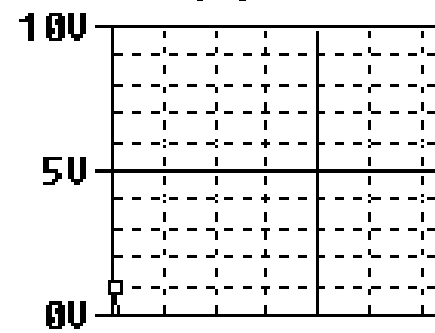
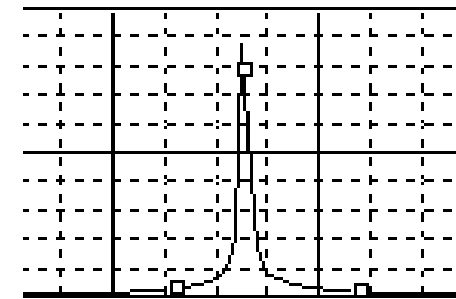
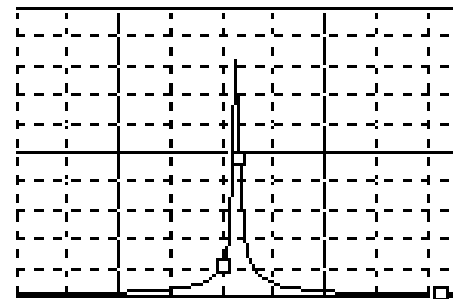


□ V(3)

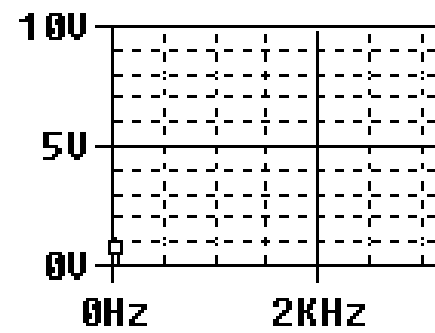
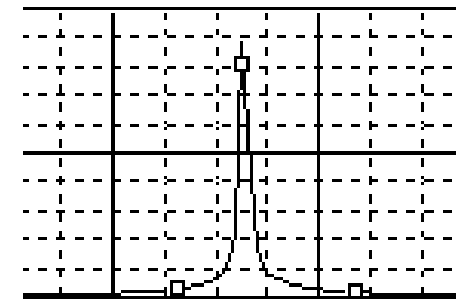
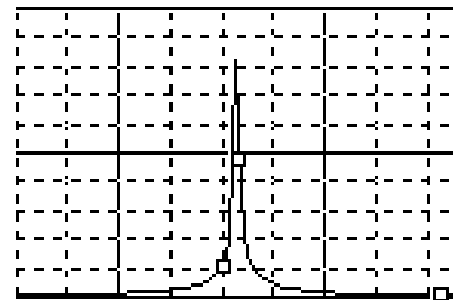
TL082



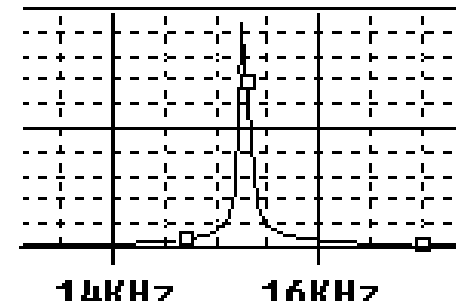
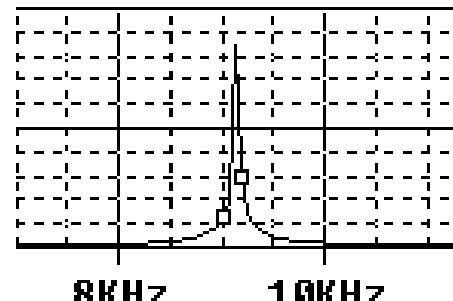
□ U(2)



□ U(1)



□ U(3)

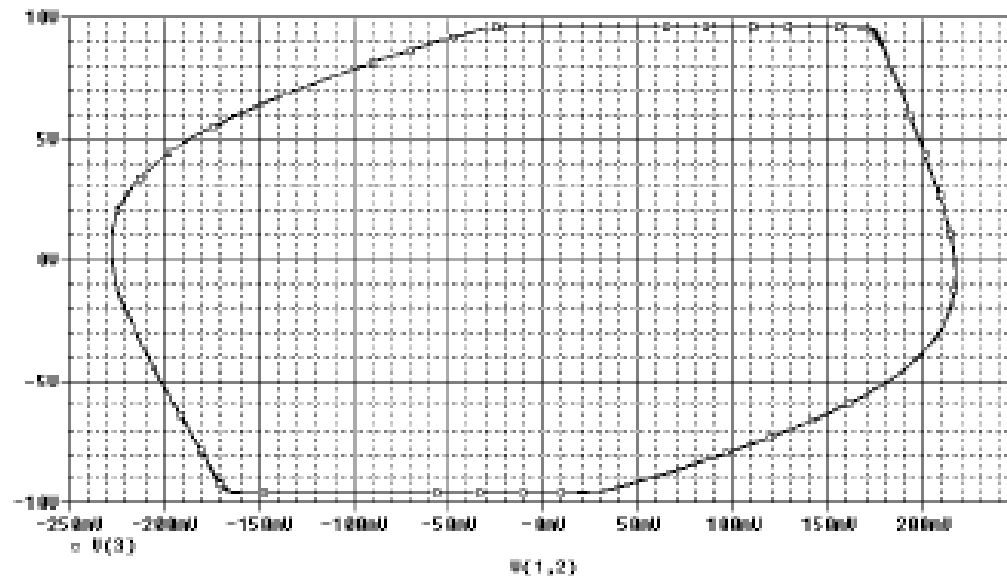


Case E6

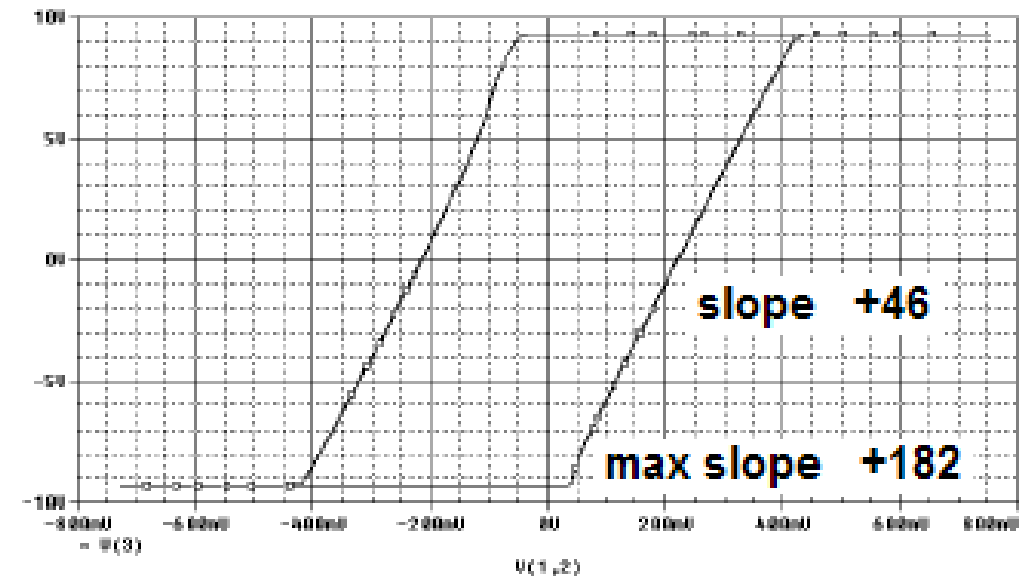
ua741

TL082

Case E6



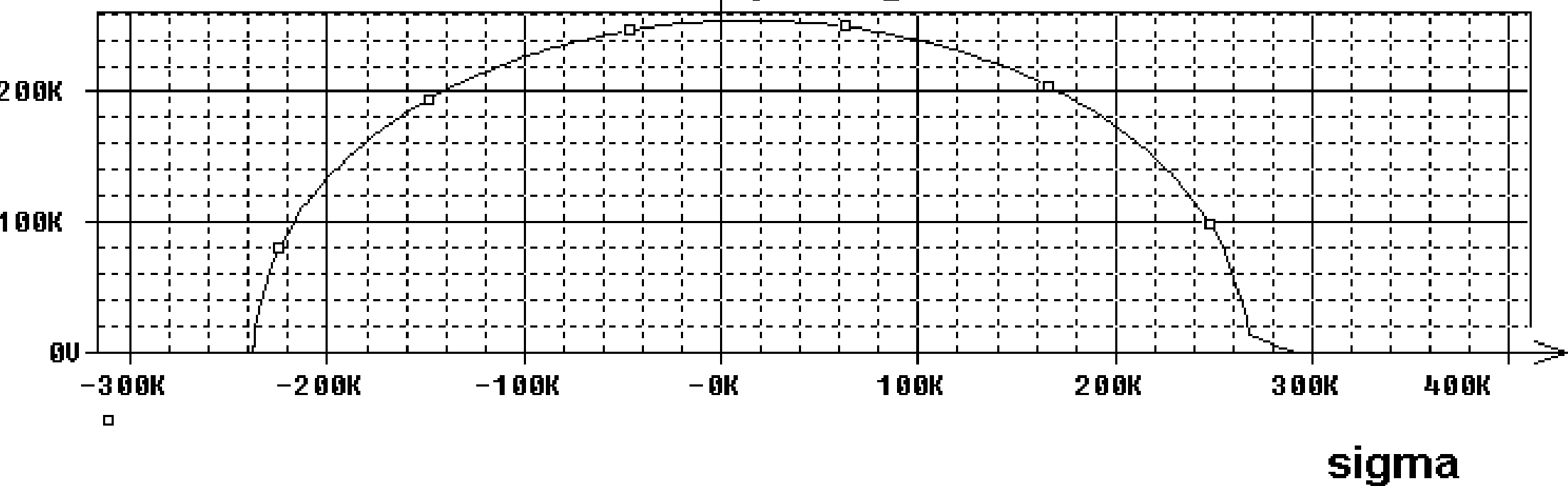
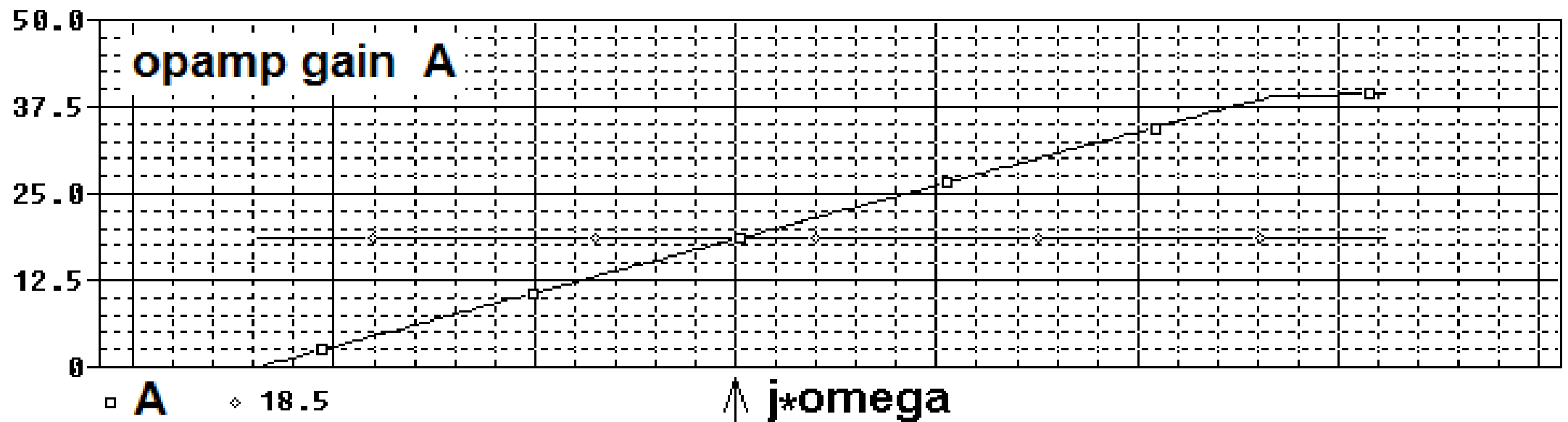
ua741



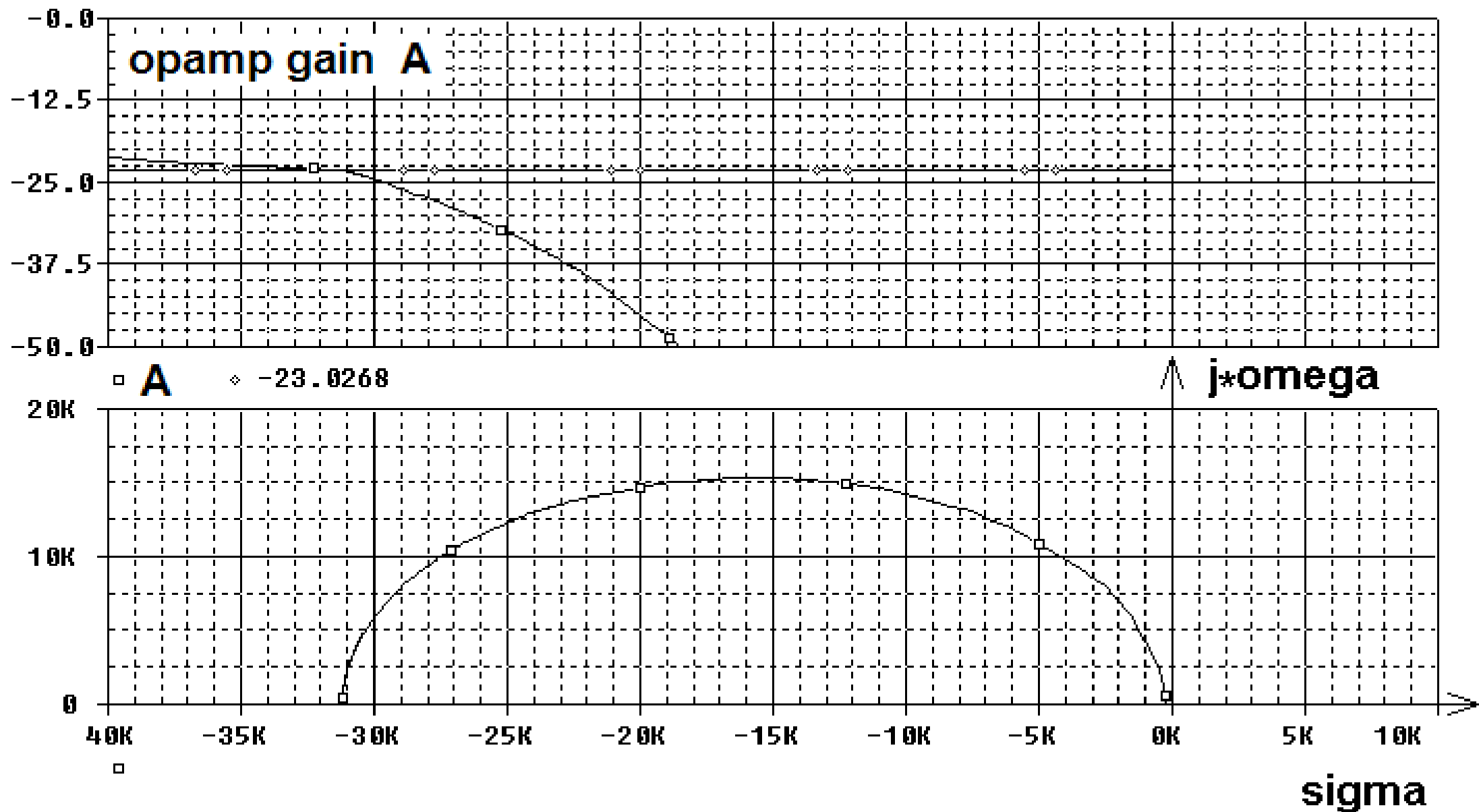
TL082

**dynamic transfer-characteristics of
operational amplifiers**

$$\text{slope: } V3 = A * (V1 + V2)$$



Case E6 complex pole-pair trajectory



Case E6 complex pole-pair trajectory

Gain A	Poles	Case E6	
0	$-0.230\text{e}+6$	$-17.7\text{e}+3$	$0.00\text{e}-01$
+46	$0.589\text{e}+6$	$0.126\text{e}+6$	$-13.5\text{e}+3$
-46	$-1.65\text{e}+6$	$-19.7\text{e}+3 \pm j 14.8\text{e}+3$	
+182	$4.22\text{e}+6$	$24.5\text{e}+3$	$-9.67\text{e}+3$
-182	$-5.21\text{e}+6$	$-6.44\text{e}+3 \pm j 12.3\text{e}+3$	
+1e+9	$26.0\text{e}+12$	$-0.500\text{e}+3$	$0.00\text{e}-01$
-1e+9	$-26.0\text{e}+12$	$-0.500\text{e}+3$	$0.00\text{e}-01$
1.0E+12	$-0.500\text{e}+3$	$0.00\text{e}-01$	$0.00\text{e}-01$

1 Colpitts Oscillator Family

2 Amplifiers and Oscillators

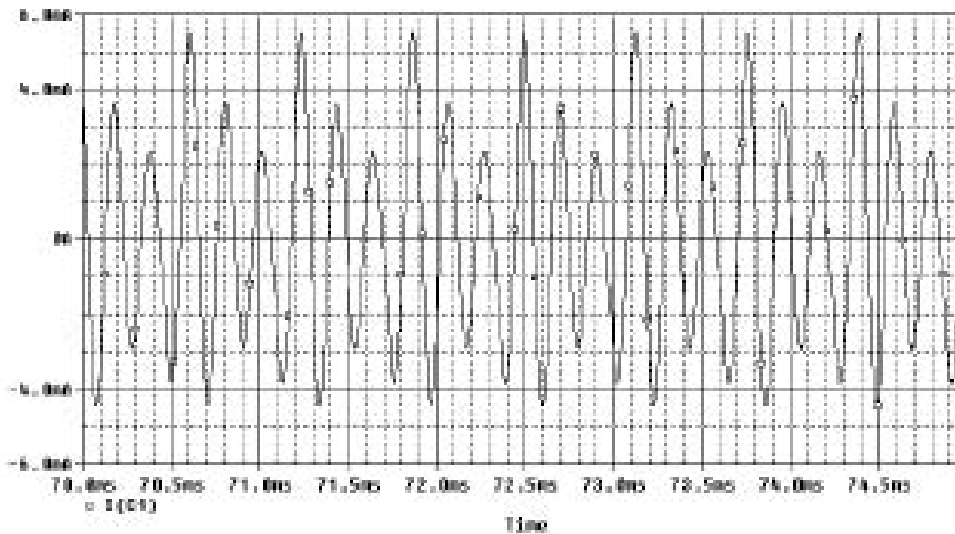
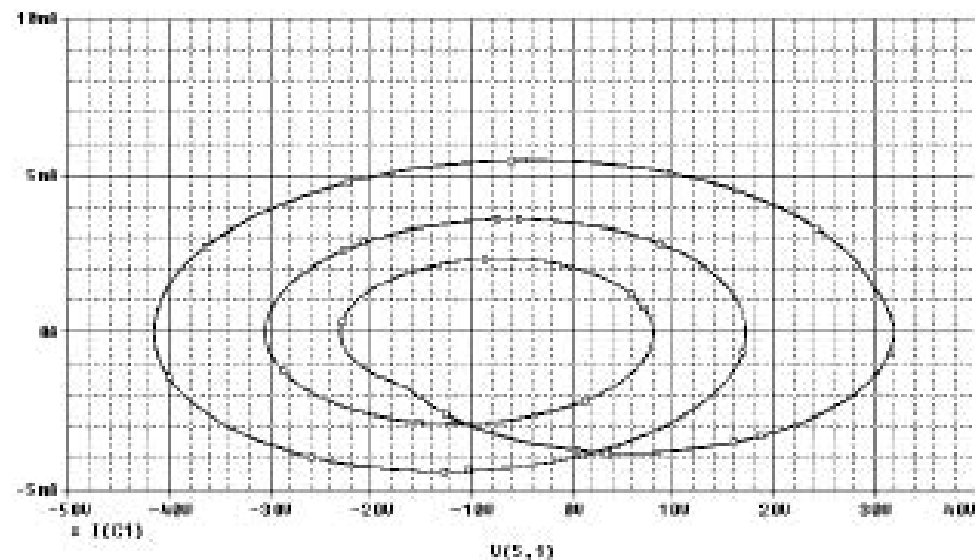
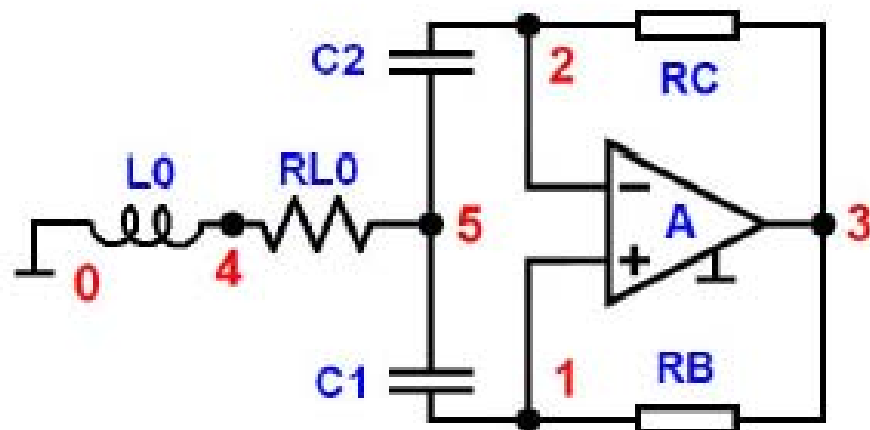
3 Colpitts Oscillators based on Transistors

4 Colpitts Oscillators based on Amplifiers

5 Conclusion

Conclusion

- The Colpitts oscillator family is investigated.
- New oscillator topologies with memory components in both positive and negative feed-back path of a perfect operational amplifier are presented.
- The complex frequency plane trajectories of the eigenvalues of the linearized Jacobian of the differential equations modeling topologies with only one nonlinearity are studied in order to obtain knowledge about the mechanism behind the oscillations.
- A real pole is moving in the left half plane and a complex pole pair is moving between the right and the left half plane so that energy balance is obtained.



```

*      XOPAMP 1  2  31  32  3  uA741
*      XOPAMP 1  2  31  32  3  TL082
*
*      VP  31  0  dc +10
*      VN  32  0  dc -10
*
* ----- Passive RLC elements
*
*  GOP    1  2  1  2      0.0000000000000000E-01
*  RL0    5  4              5.0000000000000000E+01
*  L0     4  0              1.0000000000000000E-01
*  C1     1  5              4.8127562230000000E-09
*  C2     2  5              5.3475069140000000E-09
*  RB     1  3              8.0000000000000000E+02
*  RC     2  3              8.0000000000000000E+02
*  RA     1  0              800
*  RD     2  0              800

```


Thank you for your attention

